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# The Relationship of Problem-Solving Styles to the Factor Composition of Tests

JOHN W. FRENCH

Office of Naval Research Contract Nonr-2214(00)
Project Designation NR 151-174
John W. French, Principal Investigator

Educational Testing Service
PRINCETON, NEW JERSEY

May 1963

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## Abstract

This study was undertaken to learn more about the way in which the characteristics being measured by a test vary with the kind of examinee taking the test or with the problem-solving style he uses in approaching test problems.

Briefly, the procedure for this study included the following steps: (1) The subjects took 15 tests which would later be examined by factor analysis. (2) In order to find out what problem-solving styles the subjects used, they were required to fill out a questionnaire about their background and their approach to test problems, and were interviewed while they solved items similar to ones they had faced on the tests. In all, more than 100 items of information about each subject were gathered. (3) As an aid in recognizing the important problem-solving styles in these data, the intercorrelations of the interview, questionnaire, and test variables were factor analyzed. (4) These variables, after being grouped and selected by the factor analysis, were used to divide the subjects into 17 different pairs of subsamples representing different problem-solving styles or different background characteristics that might be expected to affect the way in which a person solves problems. (5) All subsamples in the 17 pairs and also the whole group were then used in performing separate factor analyses of the same 15 tests, in all of which five factors were extracted and rotated. (6) Factor loadings and factor intercorrelations were compared for the two subsamples in each pair.

The problem-solving approaches used for dividing many of the pairs of subsamples distinguished some kind of systematizing approach from a scanning

approach. This is a distinction emphasized by Bloom and Broden and probably related to Gardner's Focusing vs. Scanning and Witkin's Analytic Attitude or Field-Independence. While some of the divisions into pairs of subsamples revealed no substantial differences either in the loadings of the 15 tests on the five factors or in the intercorrelations of the factors, many interesting differences occurred. In particular the development of a systematic approach to solving the items of a test frequently reduced the loadings of that test on the factor which usually characterized it best. Also, for subjects using a systematic rather than an intuitive or scanning approach to test items, the space factor was usually found to be relatively less correlated with the verbal and mathematical factors and the verbal and mathematical factors were found to be more highly correlated with each other. An attempt is made to account for these findings psychologically by supposing that systematic persons develop specialized techniques for solving the visible, concrete spatial problems that are quite different from the symbolic techniques that they can use for solving problems in either of the symbolic areas, verbal and mathematics.

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# THE RELATIONSHIP OF PROBLEM-SOLVING STYLES TO THE FACTOR COMPOSITION OF TESTS[1]

When an ability or achievement test is constructed, its author usually assumes, or at least hopes, that his creation will measure the same thing for all examinees. An often talked about exception to this desirable quality of a test is the case of a fourth grader and a college student who take the same test of addition. We think such a test is one of reasoning for the younger subject, while it is one of speed for the older one. Some specific data on this appears in Balinski (1941). Large age differences, however, are not the only differences that affect the nature of the factor being measured by a test. Some tests of higher mental processes are solved in one way by some subjects and in another way by other subjects (Bloom & Broder, 1950, Ch. 3; Lucas, 1953). This means that the tests may be measuring different abilities for some subjects than for others, and so it follows that tests will have different correlations with one another for different kinds of groups of subjects. Therefore, since factor loadings of the tests depend on these correlations, we cannot expect factor loadings to be invariant from one population to a different population (Thurstone, 1947, p. 360). It seems possible that the factorial composition of test problems involving higher mental processes often appears complex, not only because they require several different kinds of abilities in their solution, but also because they measure something different for examinees who solve them by using different methods. This study was initiated because an investigation of this situation seemed likely to lead to worthwhile information about individual differences in problem-solving styles, an appreciation of the different things a test measures for different subjects, and an understanding of the extent to which factor analysis reflects qualitative differences in

individuals' reactions to tests as well as to differences in the nature of the tests themselves.

Briefly, the procedure for this study included the following steps: (1) The subjects took 15 tests which would later be examined by factor analysis. (2) In order to find out what problem-solving styles the subjects used, they were required to fill out a questionnaire about their background and their approach to test problems, and were interviewed while they solved items similar to ones they had faced on the tests. In all, more than 100 items of information about each subject were gathered. (3) As an aid in recognizing the important problem-solving styles in these data, the intercorrelations of the interview, questionnaire, and test variables were factor analyzed. (4) These variables, after being grouped and selected by the factor analysis, were used to divide the subjects into 17 different pairs of subsamples representing different problem-solving styles or different background characteristics that might be expected to affect the way in which a person solves problems. (5) All subsamples in the 17 pairs and also the whole group were then used in performing separate factor analyses of the same 15 tests, in all of which five factors were extracted and rotated. (6) Factor loadings and factor intercorrelations were compared for the two subsamples in each pair.

Before the work was started, the following hypotheses about specific tests were written down:

1. Verbal Analogies will give rise to a reasoning subsample and a knowledge subsample. For the reasoning group as compared to the knowledge group, Verbal Analogies will load the mathematics reasoning factor higher, and the mathematics reasoning factor will have a higher correlation with the verbal factor.

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1. Verbal Analogies will give rise to a reasoning subsample and a knowledge subsample. For the reasoning group as compared to the knowledge group, Verbal Analogies will load the mathematics reasoning factor higher, and the mathematics reasoning factor will have a higher correlation with the verbal factor.

2. Cubes, Spatial Orientation, and Punched Holes will give rise to a spatial sense subsample and a verbal reasoning subsample. For the spatial sense group as compared to the verbal reasoning group, the spatial and visualization factors will be more orthogonal to the mathematics reasoning and verbal factors, and the group means for the spatial and visualization tests will be higher.

3. Letter Grouping and Number Series will give rise to a system subsample and a trial and error subsample. For the system group there will be an induction factor; for the trial and error group there will not.

4. Mathematics Problems will give rise to an original reasoning subsample and a text-book methods subsample. For the original reasoning group there will be a mathematics reasoning factor; for the text-book methods group there will not.

Later in this report these hypotheses will be compared with the experimental results.

## Selection of Tests

It was considered desirable to select tests known to have loadings on factors which are of general interest to researchers, which are involved in cognition rather than perception or pure speed, and, preferably, which have some demonstrated importance in intellectual achievement. A history of some confusion in the interpretation of a factor was regarded as an asset in this kind of study, since this left wide open the possibility that differences in problem-solving styles would affect factor loadings. It was also considered desirable to use some tests that straddle two or more of these factors. The five factors that were selected and the five tests selected to represent them most purely are as follows:

| Factor | "Pure" test |
|---|---|
| Verbal Comprehension | Vocabulary |
| General Reasoning | Mathematics Problems |
| Space | Cards |
| Induction | Letter Grouping |
| Visualization | Surface Development |

A selection was made of ten other tests which would load these factors less purely or would straddle two or more of them. The 15 tests are named and described below. The items that were used in the interview situation are presented in Appendix A. These items will serve as samples of the kinds of items in the test battery, although these particular items do not appear in the tests themselves. Sample items from Vocabulary and from Ship Destination are missing, because these were not used in the final form of the interview. Following each test name below, appear the code letters that will be used to refer to these tests. Information about factor loadings previously found for all of the tests may be found in French (1951). A phrase indicating the factors usually found to be associated with each test is given at the end of the test description.

1. Vocabulary, VOC
   A 5-choice synonym test of general vocabulary having a moderately wide range of item difficulties. 36 items, 7 minutes. Pure on Verbal Comprehension.

2. Mathematics Problems, MAT
   A test of fairly conventional word problems all of which are solvable by arithmetic, but for a few of which the use of simple equations would help. 15 5-choice items, 15 minutes. Pure on General Reasoning.

3. Cubes, CUB
   A Thurstone test in which each item presents 2 drawings of a cube with designs on its faces. Assuming no cube can have 2 faces alike, the subject indicates which items show 2 drawings that can be of the same cube and which ones show 2 drawings that cannot be of the same cube. 44 items, 5 minutes. Space with some Visualization and Induction.

4. Punched Holes, PUN

A Thurstone test in which each item includes successive drawings illustrating 2 or 3 folds made in a square sheet of paper. A drawing of the folded paper shows where 1 or 2 holes are punched in it. The subject draws the sheet as it would appear fully opened. 10 items, 5 minutes. Mainly Visualization.

5. Letter Grouping, LET

A form of Thurstone's test in which each item presents 4 sets of 4 letters each. The task is to find the rule which relates 3 of the sets to each other and to mark the one which does not fit the rule. 25 items, 3 minutes. Pure on Induction.

6. Surface Development, SUR

This is Thurstone's test in which there are drawings of solid geometrical forms. With each drawing there is a diagram showing how a flat pattern might be cut and folded so as to make the solid form. The subject is to indicate which lettered edges on the solid form correspond to numbered edges or folds in the pattern. 12 patterns totalling 60 items, 10 minutes. Mainly Visualization.

7. Verbal Analogies, VER

Each item consists of 2 words which have a certain relationship to each other followed by 5 numbered pairs of related words. The task is to circle the one of the numbered pairs which illustrates the same relationship as the original pair. 16 items, 10 minutes. Verbal Comprehension with some Induction and General Reasoning.

8. Ship Destination, SHI

A test by Christensen and Guilford in which the task is to use knowledge of the position of a ship in a diagram with respect to a port, knowledge of wind direction, ocean current, and direction of travel to compute effective distance to port following given rules. 48 items, 15 minutes. General Reasoning with some Space.

9. Cards, CAR

A Thurstone test in which each item gives a drawing of a card cut in some shape and sometimes having holes punched in it. To its right are 6 other drawings of the card, some merely of the card in different rotational positions and some of the card turned over. The subject indicates which ones are "like" the stimulus card (not turned over). 18 cards, 108 scorable units, 5 minutes. Pure on Space.

10. Reading, REA

Four paragraphs representing different kinds of reading were the basis on which the subjects responded to a total of 15 5-choice questions. 15 minutes. Verbal Comprehension with some General Reasoning.

11. Concealed Figures, CON

An adaptation by Thurstone of the Gottschaldt Figures Test. Each row of the test has a simple geometrical figure at the left side followed by 4 complex figures. The task is to mark each complex figure whether it does or does not contain the simple figure. 42 rows, 168 scorable units, 8 minutes. Space with several other factors.

12. Figure Analogies, FIG

    One of 5 geometrical figures is to be selected as the fourth term in a proportion such that it bears the same relation to the third term as the second did to the first. 30 items, 5 minutes. General Reasoning, Induction, and Space.

13. Spatial Orientation, SPA

    Each item presented 2 drawings of shore objects as seen over the prow of a boat. By comparing the position of shore objects with respect to the prow the subject was to judge the vertical, horizontal, or tilting motion of the boat between pictures. The subject reacted by choosing 1 of 5 responses, each of which showed a dot representing the first position of the prow and a dash representing the second. 54 items, 10 minutes. Two additional scorings of this test concerned separating the errors made in recognizing tilt from errors on other aspects of the test. Space and Visualization.

14. Number Series, NUM

    Each item consisted of a series of seven 1- or 2-digit numbers. The eighth member of the series was to be selected from among the 5 choices offered. 30 items, 10 minutes. General Reasoning with some Induction.

15. Marks, MAR

    A test by Thurstone in which each item gives 5 rows of places and gaps. In the first 4 rows one place is marked according to a rule. The task is to discover the rule and to mark one of the places in the fifth row accordingly. 20 items, 8 minutes. Induction with some Space and General Reasoning.

## Administration of the Tests

The tests were administered to male students in the eleventh and twelfth grades of the college preparatory program at Princeton (New Jersey) High School and students enrolled in Princeton University. These subjects were paid for their participation in the experiment. A total of about 220 took the tests; 177 were used in the analysis.

To make it possible to schedule an individual interview with each subject within a few days after the testing period it was necessary to spread the testing out, one or two subjects being tested at a time. This was done by having them take the tests individually by timing themselves with an electric timer.

## The Interview and Questionnaire

The items shown in Appendix A, which are like those in each of the 15 tests except Vocabulary and Ship Destination, were presented to each of the subjects individually within a few days after he took the tests. The subjects were asked to respond to each item, doing all their thinking aloud. In addition, the interviewer asked a few specific questions which seemed helpful in reaching a satisfactory understanding of the subject's methods or styles in solving each kind of problem presented to him.

The interviewing procedure was built up and continually revised during the processing of about 40 subjects whose test scores and interview protocols were not used in the analysis. During this period it was decided what kinds of things should be observed, what test items were best able to bring out a subject's characteristic behavior, and what questions should be asked in order to facilitate interpretation of the subject's methods for solving the problems that were set for him. Although the decision on the kinds of behavior to be recorded was decided entirely on the basis of what seemed especially distinctive during the interviews, there was, nevertheless, a relationship between the kinds of behavior observed in this study and characteristics of problem-solving behavior reported in the literature and discussed in the next section.

Items from the Vocabulary and Ship Destination tests were not used in the interview, because no satisfactory differences in methods of working on these tests could be observed.

During the course of the development of the procedure, some 20 interviews were carried out jointly by the writer and the interviewer, who made independent judgments of the subjects' responses. When substantial disagreement occurred, interview test items were changed or eliminated, the nature of the ratings were

redefined, or special questions for the subject were incorporated in the interview procedure. The final interview form including the special questions is presented in Appendix B. A measure of reliability of the interview observations in their final form made by correlating the judgments of two observers would have been desirable, but would have added very substantially to the cost of the project.

The interview yielded 105 ratings or variables. Some of these were necessarily dichotomous because of their essentially qualitative nature; some of them were ratings on a 3-point to 7-point scale or were enumerations of specific ideas or words spoken by the subject. A multi-point scale was used for a rating whenever possible in order to permit conversion to a dichotomy with which the group of subjects could be split into two nearly equal divisions.

After the interview, the subjects completed a questionnaire asking them about their school and home interests, academic interests and background, their abilities, their ambitions, and the way they themselves thought that they solved problems. While most of these questions did not pertain directly to problem-solving styles, they concerned characteristics of the individuals that might be expected to relate to problem-solving styles. In any case it was thought best not to limit the definition of subsamples entirely to the interview observations. The questionnaire is included as Appendix C. It yielded an additional 32 variables. Most of these consisted of an item that could be checked or not checked or an activity that could be named or not named. That is, most of the variables yielded by this questionnaire were dichotomies, many of which, however, split the total group of subjects into poorly balanced subgroups.

## The Selection of the Experimental Dichotomies

Experimental dichotomies constructed from single variables or combinations of variables were to be used for dividing the total sample of subjects into pairs of contrasting subsamples. Since the interview and questionnaire provided a total of 137 variables, it seemed neither wise nor possible to decide about the dichotomies on the basis of simple inspection or common sense.

All variables which were not already dichotomies were dichotomized as closely as possible to the center of their distributions. The 15 test scores plus two extra scores for the Spatial Orientation test were also dichotomized. For the resulting 154 dichotomies the matrix of tetrachoric intercorrelations based on 177 cases was computed. Variables shown by these correlations to be mere repetitions of others and also some variables for which the split was particularly unbalanced were now dropped from further analysis. The remaining 125 variables were factored. While the ratio of 177 cases to 125 variables is extremely small, factor analysis was considered to be a reasonable procedure because it was being employed in this instance merely as a technique to suggest groups of variables that could be combined into short, rough scales for separating the subjects into pairs of subsamples. Twenty-five principal component factors were extracted using communalities estimated by iteration. The decision to stop extracting factors was based on the size of the eigenvalues. The factors were then rotated orthogonally by the varimax method.[2] While the total group of subjects could have been divided into subsamples on the basis of any one of the variables, each of these 25 factors was thought to represent a particularly fruitful independent basis for the division. Actually only the 17 factors which seemed to have psychological meaning were used for this purpose.

Because of the enormity of the tables of intercorrelations and factor loadings, they will not be reported here. Some of the information from these tables, however, is used to describe the pairs of subsamples that were created. The tables headed "Pair 1," "Pair 2," etc. are devoted to each of these pairs of subsamples derived from 17 of the 25 factors. The heading of each table also contains the name of the factor (pair) and the names of the 1, 2, 3, or 5 variables on the basis of which the total sample of subjects was divided into two subsamples. These variables are ordinarily the ones with highest loadings on one of the 17 factors, although variables highly correlated with one another were sometimes avoided. For Factor 1 a special exception was made. For this factor the test scores themselves had the highest loadings. Since it was the test scores that were used in the subsequent part of the analysis, the division was made on the basis of the highest non-test variables. These happened to be interview variables concerned with mathematics problems. Finally, in the top part of each table, the factor responsible for the division is further described by presenting its loadings for college vs. high school and its loadings for the test scores that are of particular interest. (The 17 "pair tables" are located on pages 23-39.)

Inspection of the headings on the 17 "pair tables" will show that many of the subsample divisions, while being developed from orthogonal factors, nevertheless seem to fall loosely into a category that can be called "systematizing" or "analyzing" vs. "scanning." The pairs in this category are Numbers 2, 3, 5, 6, 7, 8, 11, 15, 16 and 17. Other pairs are as follows:

Pair 1, which is divided by an aptitude, mathematics or, perhaps, something more general, is the one mentioned in the preceding paragraph.

Pairs 4 and 13 are divided by interest variables: interest in verbal subjects and in art, respectively.

Pairs 9 and 12 are activities peculiar to the reading test. Pair 9 can, perhaps, also be considered to represent a kind of systematizing.

Pair 14, represents a lack of visualization indications. It could be considered a kind of negative measure of systematizing, but there were not adequate negative correlations to justify this.

The prevalence of problem-solving styles that seem concerned with systematizing or scanning suggests that there may be a relationship between the problem-solving styles observed in this experiment, particularly for the spatial tests, and the cognitive style of focusing vs. scanning which has been found to effect perception of size and susceptibility to illusions (Gardner et al., 1959; Gardner, 1961; Gardner & Long, 1962).

Since the various kinds of systematizing observed in this study were essentially uncorrelated with one another, being derived from orthogonal factors, they will be regarded as separate problem-solving styles. It is possible that different kinds of tests or techniques of observation would yield approaches to problems that seem psychologically to be less alike. Especially for Pairs 2, 7, 8, 15, and 16 the observed problem-solving style can best be termed "analyzing" in contrast to a global way of perceiving. A dimension which sounds like this as it is described has been discussed by Witkin et al. (1962) and has been found to be generally positively correlated with intellectual ability (Witkin et al., 1954, 1962; Gardner, Jackson, & Messick, 1960). The means of the subsamples given at the bottoms of the "pair tables" confirm this positive relationship consistently. However, the analytic approach was not found to be consistently successful for spatial tests or even for the tests with which the analytic behavior was observed. In particular, the subsamples using analytical behavior on concealed Figures (Pair 8) and Cubes (Pair 15) made lower mean scores on those tests

than did the subsamples using global behavior. Since Concealed Figures is very similar to the test that Witkin and his associates used for measuring Analytic Attitude or Field-Independence, there appears some doubt that the behavior being observed here is, in fact, the same as that described by Witkin.

## Factorization of the Subsamples

After the 34 subsamples had been defined as indicated at the top of the 17 "pair" tables, the matrix of intercorrelations of the 15 test scores for each of these subsamples and for the total sample were factored. In all cases five factors were extracted. To stipulate the same number of factors in advance for all 35 analyses effected a considerable saving in cost. The number five was used because the tests had been chosen so as to include variance from five known factors. Examination of the eigenvalues and residuals gave no indication that a different number of factors would have been preferable.[3]

The first rotation for each of the 35 factorizations was by varimax to an orthogonal solution. Again, because of space considerations, it is impossible to report the 35 sets of intercorrelations and factor loadings, unrotated or rotated. The intercorrelations and the varimax rotated solution for the whole group is shown as Appendix D. Many but not all of the subsample solutions looked very much the same as the solution for the whole group. That is, the five factors as they appeared in many (but not all) of the subsamples justified similar factor names, and the individual tests had similar patterns of loadings. For other subsamples, however, the loadings of all tests simultaneously veered away from the loadings that had been found for the total group. Comparisons from one subsample to another were completely without precision. Since precise comparisons of factor loadings were of central importance to this study, a rotational technique which insured congruency of the factors was essential. To achieve this, it was planned

to rotate four of the factors to specified marker variables that would define the positions of the factors. With one exception, the marker variables selected were those with the highest loadings in the varimax solution for the whole group. The Concealed Figures test, CON, actually had the third highest loading on a factor recognized as a Space-Visualization factor, but this test was not used as a marker, because it has not always been clearly identified with Space or Visualization. The marker tests used were as follows:

Factor A: PUN, SUR, and CAR

Factor B: VOC, VER, and REA

Factor C: MAT and NUM

Factor D: SHI and MAR

Factor E was rotated so as to be orthogonal to A, B, C, and D.

A quartimax rotation was applied first to produce the best orthogonal rotation to the four sets of marker tests. Factor E was then permanently set orthogonal to these four. A patterned oblimax rotation was then applied to Factors A, B, C, and D to bring these factors as close as possible to the marker tests.[4]

With the exception of Factor E, the resulting rotations were oblique, often extremely oblique, correlations between factor axes ranging from .28 to .80. While a good many incomprehensible differences could still be found in the factor patterns when comparing one subsample with another, the picture was greatly clarified. The principal variables identifying the factors retained pretty much the same loadings from subsample to subsample, while single tests would shift their highest loadings from one factor to another or the intercorrelations among the factors would change.

For the total sample, Table 1 shows the loadings for the oblique rotation and the intercorrelations of the factor axes. The factors have been named as follows:

## Table 1

## Factor Results for the Total Sample

Factor loadings after rotation determined by marker tests (denoted by *)

| | Test Name | Code | Factor Loadings A | B | C | D | E |
|---|---|---|---|---|---|---|---|
| 1. | Vocabulary | VOC | -.01 | .68* | -.00 | -.11 | .02 |
| 2. | Mathematics Problems | MAT | .11 | .22 | .41* | -.08 | -.15 |
| 3. | Cubes | CUB | .46 | .17 | -.14 | .01 | .21 |
| 4. | Punched Holes | PUN | .42* | -.01 | .01 | .15 | -.07 |
| 5. | Letter Grouping | LET | .10 | .07 | .25 | .08 | .45 |
| 6. | Surface Development | SUR | .80* | .08 | -.10 | -.17 | -.06 |
| 7. | Verbal Analogies | VER | .03 | .60* | -.03 | -.02 | -.04 |
| 8. | Ship Destination | SHI | .06 | .16 | .05 | .31* | -.02 |
| 9. | Cards | CAR | .57* | -.08 | .03 | -.01 | .10 |
| 10. | Reading | REA | .02 | .62* | -.08 | .04 | .03 |
| 11. | Concealed Figures | CON | .43 | .02 | -.02 | .15 | .11 |
| 12. | Figure Analogies | FIG | .40 | .06 | -.02 | .15 | .06 |
| 13. | Spatial Orientation | SPA | .37 | .17 | -.09 | .12 | -.05 |
| 14. | Number Series | NUM | -.10 | -.11 | .63* | .02 | .04 |
| 15. | Marks | MAR | -.12 | -.08 | -.00 | .52* | .00 |

Correlation of factor axes:

| | A | B | C | D |
|---|---|---|---|---|
| B | 44 | | | |
| C | 54 | 69 | | |
| D | 67 | 60 | 65 | |
| E | 00 | 00 | 00 | 00 |

Factor A, (marked by PUN, SUR, and CAR). Space-Visualization. In selecting the 15 tests for this study, it was intended that Space and Visualization would appear as separate factors, but they did not do so. As could be seen from factor plots made from the data in Table 1 and from the data for some of the subsamples, the spatial and visualization tests are intermingled. Therefore, failure to isolate the two factors is not merely a defect of the rotation.

Factor B, (marked by VOC, VER, and REA). Verbal Comprehension.

Factor C, (marked by MAT and NUM). Mathematics. MAT was intended to associate with SHI to define the General Reasoning factor as it has in many studies carried out in Guilford's laboratory (Green et al., 1953; Frick et al., 1959, etc.) but it did not do so. Its association with NUM is reasonable, but the factor seems to be one of number facility or mathematical content rather than one of pure reasoning.

Factor D, (marked by SHI and MAR). Reasoning. If MAR and LET had appeared on the same factor, it could have been interpreted as induction. However, since SHI is a reasoning test but probably not a test of inductive reasoning, it will serve the purposes of this study to call Factor D a reasoning factor without specifying what kind of reasoning is involved.

Factor E, (orthogonal to A, B, C, and D). No interpretation. LET has the highest loading, but data for making an interpretation are very slight indeed.

The matrix of factor loadings in Table 1 may be compared with the results given for the subsamples. Only selected figures are given for the subsamples; otherwise the mass of numbers would make comparisons very cumbersome. The table for each pair presents the following data for each subsample:

1. Loadings of .20 and higher for each of the five factors.
2. All loadings for tests involved in defining the subsamples. These appear in parentheses when less than .20.

3. Intercorrelations of factor axes.
4. The subsample mean and standard deviation for some of the tests including those involved in defining the subsample. These are given to provide a fuller understanding of the kind of subjects falling into each subsample.

Discussion of the Subsample Results

Pair 1, Has Less vs. More Trouble with Mathematics Problems. The highest loadings for the factor resulting in Pair 1 were among the test scores themselves, but these were not used in defining the division of subsamples, because doing so would create some spurious restrictions of range. Nevertheless, this mathematical factor is closely related to general intellect and maturity in this group. Not only for Mathematics Problems, MAT, but for all of the tests, the mean scores given in the lowest section of the table are higher for the subjects who had "less trouble with Mathematics." Even though the variables used in creating this pair of subsamples are interview variables, the distinction made here is more one of problem-solving capability than of problem-solving style.

The primary effect of this factor was to concentrate the students with mathematical ability into one subsample to such a degree that the distribution of MAT scores became crushed against its ceiling of 15. This effect reduced the variance on MAT and caused it to drop from its usual place in the factor pattern. Look first at the group having "more trouble" and then at the group having "less trouble" with Mathematics. Factor C, which was called "Mathematics" for the total group, has become dominated by Letter Grouping. It has moved away from (has a lower correlation with) Space-Visualization and has moved toward Verbal Comprehension. This change is reasonable, because the new Factor C, consisting of Letter Grouping and Number Series, is probably inductive in nature calling for the formation and trial of hypotheses. Such an activity certainly requires less

spatial visualization than the mathematics problems, and the mental manipulation of hypotheses in verbal terms may account for its raised correlation with Verbal Comprehension. It is possible that there would have been no disturbance in the factorial pattern for this pair of subsamples had it not been that MAT was too easy for these subjects. In factor studies it is usually hoped that there will be factorial "invariance"; that is, it is hoped that the nature of the factors will be relatively independent of the particular tests included in the study. In an instance of this kind where one test was in effect simply deleted from the battery, the factors would usually be expected to remain invariant. However, invariance failed to appear, probably because there were not enough tests to define the factors. Without a well-functioning mathematics problem test, there was not enough common variance in mathematics to define a factor.

Pair 2, Uses Rule in Solving Cards Items. Division of the sample into a pair of subsamples according to whether or not the subjects used a rule for analyzing Cards items produced no appreciable differences in the factor loadings or any large differences in the intercorrelations among factors. The reason for a negative result for this pair of subsamples, or for any other pair of subsamples, cannot, of course, be fully determined. The implication here is that Cards measures close to the same thing whether or not the subjects use a rule in responding to the items. It is possible, however, that the interview simply failed to make any reliable discrimination with regard to behavior on this particular test.

Pair 3, Emphasizes Relationships in Number Series Items. This division, based on the use of relationships in solving Number Series, NUM, problems has affected, Factor C, the mathematics factor. The loading of the Mathematics Problems test has declined sharply on Factor C. Since the division of subsamples

is based on NUM, a more reasonable interpretation is that NUM moved away from the mathematics factor and is now forming a new Factor C, which appears inductive in nature. This leaves no factor that can be interpreted as Mathematics. This is the first of several pairs of subsamples showing that a systematic approach to a test tends to move the test away from the factor or other tests with which it is more usually associated.

Pair 4, Likes Verbal Subjects vs. Likes Science. This division produced no important differences, unless the reduction in the loading of Marks on Factor D can be considered significant. The pattern of mean test scores shows that those who like verbal subjects best did better on Vocabulary, while those who like science best did better on all of the other tests.

Pair 5, Uses Hypotheses for Letter Grouping Items. Although the loading of Letter Groups, LET, rose somewhat on Factor E no very important differences in factor loadings or intercorrelations appeared for this pair of subsamples. It is of interest to note that use of hypotheses on LET is associated with slightly lower ability on all of the tests including LET. This contrasts with most of the other pairs where use of rules, hypotheses, and systems are associated with higher test scores. Since this test was fairly easy, the better subjects may have realized that the methodical trial of hypotheses on it was wasteful of time.

Pair 6, Uses Hypotheses for Marks Items. As for Pair 5 the use of hypotheses is here associated with lower general ability as indicated by most of the test scores. However, in this case, use of hypotheses with Marks seems to help scores on that test slightly. For the subsample of persons who use hypotheses on Marks there is a much lower correlation between the "Marks factor," Factor D, and Verbal Comprehension. This finding is discussed further for Pair 17.

Pair 7, Uses Reasoning for Spatial Orientation Items. As seems reasonable, the use of reasoning for a spatial test shifts the highest loading for that test from Space-Visualization, Factor A, to a reasoning factor, Factor D. The effect has been to push Factor D away from Verbal Comprehension, the correlation between these two factors dropping from .79 to .22. There seems to be no obvious explanation for this, although the same drop in correlation between Factors D and B appeared also for Pair 6. For both Pairs 6 and 7 the loading of Ship Destination on Factor D drops sharply. Strictly speaking, therefore, Factor D is not the same factor in both subsamples.

Pair 8, Uses Details of Figures in Concealed Figures Items. The pattern of factor loadings is essentially unchanged by this division. However, going from not using details to using details, the intercorrelations of factors show that Space-Visualization has moved away from the others; in particular it has moved away from Verbal Comprehension. This is one instance of a very consistent occurrence found in many of the pairs. In pairs of subsamples where some systematic approach was used for a test (Pairs 2, 3, 5, 6, 7, 8, 9, 11, 15, 16, and 17) the correlation between Space-Visualization and Verbal Comprehension always goes down, sometimes drastically. In such cases the correlation between Space-Visualization and Mathematics also always goes down, except for Pair 15 where there was no mathematics factor. This finding suggests that the subjects who attempt to solve spatial or other problems by ordinary common sense, perhaps by simple inspection until a solution seems to offer itself, succeed pretty much according to their general intelligence as measured by verbal and mathematical tests. For those subjects, therefore, the correlation between Space-Visualization and the verbal or mathematics factors is high. On the other hand, the subjects who use a system for solving problems have succeeded in developing some specialization of their abilities, and so the correlations drop down.

Pair 9, Considers Each Reading Item Alternative. The subjects selected by this factor respond to reading questions only after studying each alternative. This behavior, which can be considered as a systematic trick for solving the test problems, reduces the loading of Reading on Verbal Comprehension; that is, it decreases the value of Reading as a verbal test.

Pair 11, Studies Relationships in Verbal Analogies Items. This division has resulted in no important changes in the factorial pattern. There is a sharp decline in the Space-Visualization loading of Punched Holes, but no reason for this is apparent.

Pair 12, Notes Points while Reading in the Reading Test. Mentally or actually making notes while reading in preparation for answering test questions has markedly reduced the loadings of Reading on Verbal Comprehension. Neither of the behaviors indicated in Pairs 9 or 12 have much relationship to the score on Reading, but both cause the test to decline in value as a verbal test.

Pair 13, Art or Music Activities. This factor has a strong effect on the loading of Ship Destination on Factor D. Since the meaning of Factor D is not very clear, neither is this particular change of loadings. A general rise with art or music activities in almost all of the factor intercorrelations is also present. Perhaps artistic activities are associated with an integrating effect on or a lack of specialization among the cognitive areas.

Pair 14, Few Visualization Indications. Amount of apparent visualizing while solving spatial problems was associated with no important differences in the pattern of factor loadings. There is, however, a sharp decline in the correlation of the Reasoning factor, Factor D, with both Verbal Comprehension and Mathematics. Again the behavior of Factor D seems to be hard to interpret.

Pair 15, Analytic Approach to Cubes Items. This division based on the Cubes test produced rather dramatic results. The loading of Cubes dropped from .52 to .07 on Space-Visualization. Apparently the kind of analytic behavior toward Cubes, which was observed in the interview, completely destroys the capacity of that test to measure spatial ability. At the same time, the tests loading Factor B show that Verbal Comprehension and Mathematics have collapsed into one factor. The new Factor C, loading Letter Groups and Number Series, seems inductive in nature. It is this new factor that now carries the principal loading of Cubes, suggesting that the analytic behavior of the subjects has changed Cubes from a test of space to a test of induction. This finding seems to confirm the results of an earlier study (French, 1957), where most of the conventional factors were clear, but where space and induction tests fell on one dimension. This happened with West Point Cadets, who may have approached the tests with a particularly analytical attitude.

The verbal-mathematical composite in Pair 15 was a surprise. It was not forced by the limitation on the number of factors extracted, because Factor E has so small a variance that it could have provided room for a fifth well-defined factor. The collapse of the mathematical and verbal factors is probably related to an occurrence which is consistent in all but one of the pairs where a systematic approach is used for the solution of problems (unless there is no mathematics factor as occurs for Pairs 3 and 15). These pairs are Nos. 2, 5, 6, 7, 8, 9, 11, 16, and 17. In all but one of them, Mathematics and Verbal Comprehension are more highly correlated for the systematic subsample than they are for the non-systematic subsample. For Pair 15, Mathematics and Verbal Comprehension have simply become correlated in the extreme; they have collapsed into one factor. Thus, for the systematic person, Space-Visualization is relatively

independent, while the verbal and mathematics factors are relatively close together. As discussed in connection with Pair 8, the effect on Space-Visualization can be regarded as a development of specialized techniques or approaches to spatial problems. The systematic person is also likely to attempt the solution of verbal and mathematical problems by the development of specialized techniques. Since verbal and mathematics problems are both symbolic in nature, the closing together of these factors can, perhaps, be understood by supposing that the systematic subjects can develop symbolic approaches or attitudes which help them jointly in solving both of these kinds of problems. Such techniques, being common to the symbolic verbal and mathematics factors, draw these two factors together, while they may be quite different from the techniques developed for the visible, concrete, non-symbolic spatial problems, thus leaving the spatial factor relatively isolated.

Pair 16, Geometrical Approach to Punched Holes and Surface Development. This division of subsamples was based on what seemed to be the application of similar methods to the solution of two different kinds of test items, Punched Holes, PUN, and Surface Development, SUR. The ratings on these behaviors did in fact correlate sufficiently to give rise to Factor 16. Nevertheless, the loadings for the two tests are affected in opposite ways. On Space-Visualization the loading for SUR rises from .76 to .91; that for PUN drops from .56 to .26. The loadings of Spatial Orientation and Figure Analysis also drop. Logical systems for solving spatial problems were found in Pairs 7 and 15, as well as in this one, to decrease factor loadings on Space-Visualization. There is no apparent explanation for the rise in the loading of SUR. The factor intercorrelations for this pair resemble those for Pairs 6 and 7 where Factor D moved sharply away from Verbal Comprehension. No explanation is attempted particularly because of the opposite effect in Pair 17.

Pair 17, Can List Many Hypotheses for Letter Grouping and Marks Items. In contrast particularly to Pairs 6, 7, 14, and 16, Factor D in this pair moves toward Verbal Comprehension rather than away from it. It is of particular interest to compare Pair 17 with Pair 6, because both concern hypotheses used with Marks, the test with highest loadings on Factor D. The mean test scores at the bottom of the tables show that the persons with hypotheses, whether in Pair 6 or Pair 17, do better on Marks than do their opposite subsamples. The means and the factor loadings at the top of the tables, however, show that the people with hypotheses in Pair 6 are not nearly so verbal as those with hypotheses in Pair 17. The difference is that Pair 6 concerns using hypotheses, while Pair 17 concerns the number of hypotheses which the subjects can list when asked to do so. The factor pattern shows that Marks is more of a verbal exercise for those who can state their hypotheses verbally and less of a verbal exercise for those who are merely observed to use hypotheses. Since Marks measures something a little different in each of these two groups of people, Factor D is different also and can reasonably be expected to change its intercorrelations with the other factors.

Pair 20, Faster Rejectance than Acceptance of Concealed Figures Items. No important differences in the factor patterns occur for this Pair.

## Comparison of Results with Hypotheses

It is now possible to compare the results of the study with those that were expected as listed near the beginning of this report. Each hypothesis will be repeated here and then compared to the actual results:

1. Verbal Analogies will give rise to a reasoning subsample and a knowledge subsample. For the reasoning group as compared to the knowledge group, Verbal Analogies will load the mathematics reasoning factor higher, and the mathematics

reasoning factor will have a higher correlation with the verbal factor. Results: Pair 11 comes close to the anticipated pair of subsamples, although it is not exactly like it. "Studying relationships" can be considered to be reasoning. The expected difference in loadings did not occur: -.01 to -.02. The expected difference in correlations between the mathematics and verbal factors was in the expected direction: .63 to .71.

2. Cubes, Spatial Orientation, and Punched Holes will give rise to a spatial sense subsample and a verbal reasoning subsample. For the spatial sense group as compared to the verbal reasoning group, the spatial and visualization factors will be more orthogonal to the mathematics reasoning and verbal factors, and the group means for the spatial and visualization tests will be higher. Results: Pairs 7, 15, and 16 come close to the expected discrimination, although it was expected that one pair of subsamples would represent this tendency sufficiently well. The space and visualization factors are, of course, combined instead of separate, but this does not interfere with our test of the hypothesis. In all three pairs the factor correlations are opposite to those hypothesized. The reasoning approach pulls the spatial-visualization factor away from the verbal and mathematics factors. With regard to the group means, two out of three pairs refute the hypothesis. It seems that spatial ability is better described as a specialized type of reasoning than as a kind of mysterious "spatial sense."

3. Letter Grouping and Number Series will give rise to a system subsample and a trial and error subsample. For the system group there will be an induction factor; for the trial and error group there will not. Results: The expected subsamples did not occur. Pairs 3 and 5 concern these tests, but the "system" that was used was, in fact, an intensification of a hypotheses forming the trial and error system.

4. Mathematics Problems will give rise to an original reasoning subsample and a text-book methods subsample. For the original reasoning group there will be a mathematics reasoning factor; for the text-book methods group there will not. Results: The expected discrimination was not made in the interviews; Pair 1 simply divided the group according to the amount of trouble the subjects seemed to be having.

In summary, the results did not match well with the hypotheses. Hypothesis 1 was confirmed in some degree. Hypothesis 2 was opposite to the results. Hypotheses 3 and 4 were not found to be testable with the data acquired in this study. Failure of these hypotheses is really not disturbing, since they were stated originally only to define the problem. There existed no body of theory that depended upon their confirmation.

## Summary of Findings and Conclusions

There seems to be extensive evidence here that tests, even simple "pure-factor" tests, do not measure the same things for all people. The kind of behavior most readily observed in someone taking these tests was the use of some kind of reasoned or systematic approach as contrasted to less orderly scanning and visualizing, with reliance on common sense. This overall difference in problem-solving styles is the one emphasized by Bloom and Broder (1950, see especially Appendix), and may be related to Gardner's (1959) Focusing vs. Scanning or to Witkin's (1962) Analytic Attitude or Field-Independence. For some of the tests, differences of this kind in the test-taking behavior have no relation to the test's factorial content. For a few tests, the principal loading was strengthened. Most often, however, the use of a system in solving a test reduced the usual factor loading of that test, sometimes drastically. This happened more regularly for spatial or visualization tests than for

reasoning or verbal tests. These findings are understandable in terms of the view that tests are efforts on the part of the test constructor to set up standard tasks for the subject. In some cases the systematic approach to a test may eliminate some random behavior, thereby increasing reliability and increasing the expected test loadings. More often, however, the system enables the student to respond to the test items after undergoing a task partly or entirely different from the one that the test constructor had in mind. In such cases the expected factor loadings of the test decline or vanish altogether.

Some rather general findings were also observed with regard to the intercorrelations of the factors. As compared to the factor correlations for subjects who did not use systematic problem-solving methods, the correlations for the more systematic subjects showed the Space-Visualization factor to be further off by itself and Verbal Comprehension and Mathematics to be closer together. An explanation for this was attempted by suggesting that the more reasoned problem-solving style permitted the discovery through a reasoning process of specialized techniques of a spatial nature, while the same reasoning process directed the subjects toward a common means for solving symbolic problems with either verbal or mathematical content.

Another way of thinking about changes in what tests measure is to consider as "moderator variables" the dichotomies that were used to divide the total sample into subsamples. Moderator variables are variables whose values are associated with different amounts of correlation between two other variables; thus they seem to moderate or regulate the correlation between the other variables (Saunders, 1956). Systematizing is a variable that was found to be associated with lower correlations between the test being systematized and other tests ordinarily loading the same factor. This caused a decrease in the

loadings of the test in question on that factor. Going beyond the test itself, the finding was that systematizing on any test was associated with lower correlations between spatial and other kinds of tests and higher correlations between verbal and mathematical tests. These changes in correlations resulted in corresponding changes in correlations among the factors. The above-mentioned speculations about the specialization of spatial ability and the use of symbolic reasoning to solve both verbal and mathematical problems now apply as explanations of the action of systematizing as a moderator variable. The logical sequence is this: Systematizing is a tendency which leads a person to use specialized or symbolic thought processes; this changes what the tests measure and, consequently, affects the correlations between the tests.

## Pair 1 - Finds Less vs. More Trouble with Mathematics Problems

Subjects who were marked plus on 3 or more of the following:

2. Reads problems only once
3. Does not mention trouble
5. Has no trouble deciding on method
11. When asked, reports no trouble with method
12. When asked, reports no trouble understanding the problem

Comment: The above variables have loadings on Factor 1 ranging from .32 to .52. The "college" and test variables with higher loadings (below) were not used for the division of subsamples, because to do so would spuriously curtail the variance of the test variables in the subsample factorizations.

Loadings on Factor 1: COLLEGE .67, SUR .72, VOC .44, NUM .51, MAT .76, MAR .48, LET .60

More trouble, N - 80

| A | B | C | D |
|---|---|---|---|
| SUR .74 | VOC .75 | NUM .69 | MAR .39 |
| CAR .51 | VER .60 | MAT .51 | FIG .38 |
| CON .46 | REA .59 | CUB -.25 | SHI .37 |
| SPA .44 | MAT .25 | | LET .33 |
| PUN .40 | | | CUB .23 |
| CUB .23 | | | (MAT -.11) |
| (MAT .14) | | | |

| E |
|---|
| LET .40 |
| SPA -.24 |
| (MAT -.03) |

| | A | B | C |
|---|---|---|---|
| B | .33 | | |
| C | .44 | .59 | |
| D | .72 | .64 | .63 |

| | M. | S.D. |
|---|---|---|
| SUR | 24.0 | 12.3 |
| VOC | 20.4 | 8.7 |
| NUM | 23.2 | 5.1 |
| MAR | 9.0 | 4.0 |
| LET | 13.9 | 3.5 |
| MAT | 10.8 | 3.2 |

Less trouble, N = 97

| A | B | C | D |
|---|---|---|---|
| SUR .78 | VER .59 | LET .58 | MAR .57 |
| CAR .64 | REA .50 | NUM .48 | SHI .30 |
| CUB .54 | VOC .41 | (MAT .09) | PUN .23 |
| CON .47 | MAT .30 | | LET -.23 |
| FIG .45 | SPA .25 | | (MAT .03) |
| PUN .39 | SHI .22 | | |
| LET .28 | LET -.22 | | |
| SPA .27 | | | |
| (MAT .07) | | | |

| E |
|---|
| PUN .36 |
| CON .28 |
| MAT .28 |
| VER -.21 |
| SPA -.27 |

| | A | B | C |
|---|---|---|---|
| B | .38 | | |
| C | .29 | .79 | |
| D | 47 | .44 | .59 |

| | M. | S.D. |
|---|---|---|
| SUR | 31.3 | 12.9 |
| VOC | 24.1 | 7.3 |
| NUM | 25.8 | 3.4 |
| MAR | 10.0 | 3.6 |
| LET | 15.9 | 3.9 |
| MAT | 13.5 | 2.4 |

## Pair 2 - Uses Rule in Solving Cards Items

Subjects who were marked plus on 3 or more of the following:

48. Analyzes stem of Cards items first
49. Analyzes stem and alternatives before solving
51. Uses geometrical terms
54. Accepts items by using a rule
55. When asked, reports starting with a rule

Loadings on Factor 2: COLLEGE .12, SUR .12, VOC .07, NUM .05, MAT .12, MAR .10, LET .14, CAR -.08

| Does not use rule, N = 109 | | | | Uses rule, N = 68 | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | A | B | C | D |
| SUR .76 | VOC .72 | NUM .68 | MAR .56 | SUR .83 | VER .59 | NUM .60 | MAR .57 |
| CAR .54 | REA .67 | MAT .37 | SHI .29 | CAR .67 | VOC .58 | MAT .46 | SHI .36 |
| CON .48 | VER .66 | LET .27 | PUN .23 | CUB .61 | REA .52 | FIG-.20 | FIG .28 |
| FIG .39 | MAT .25 | (CAR .05) | (CAR-.04) | PUN .52 | (CAR-.13) | (CAR .03) | LET .23 |
| CUB .38 | CUB .24 | | | FIG .45 | | | (CAR .10) |
| PUN .38 | SPA .22 | E | | CON .44 | | E | |
| SPA .37 | SHI .21 | CUB .40 | | SPA .39 | | CON .42 | |
| | (CAR-.06) | LET .38 | | | | LET .41 | |
| | | (CAR .07) | | | | SPA-.21 | |
| | | | | | | (CAR .05) | |

Does not use rule, N = 109:

| | A | B | C |
|---|---|---|---|
| B | .43 | | |
| C | .56 | .63 | |
| D | .68 | .56 | .64 |

| | M. | S.D. |
|---|---|---|
| SUR | 26.3 | 13.0 |
| VOC | 21.7 | 8.6 |
| NUM | 24.4 | 4.4 |
| MAR | 9.2 | 3.7 |
| LET | 14.6 | 3.9 |
| MAT | 12.0 | 3.2 |
| CAR | 64.9 | 21.4 |

Uses rule, N = 68:

| | A | B | C |
|---|---|---|---|
| B | .41 | | |
| C | .41 | .75 | |
| D | .52 | .59 | .60 |

| | M. | S.D. |
|---|---|---|
| SUR | 30.6 | 12.9 |
| VOC | 23.5 | 7.5 |
| NUM | 25.0 | 4.5 |
| MAR | 10.0 | 4.0 |
| LET | 15.5 | 3.7 |
| MAT | 12.7 | 2.8 |
| CAR | 69.0 | 24.0 |

## Pair 3 - Emphasizes Relationships in Number Series Items

Subjects who were marked plus on 3 or more of the following:

86. Starts number series items by observing relationships
88. Tries high number of relationships
90. Does not try patterns that skip or do not account for all numbers
93. Tries multiplying and dividing rather than only adding and subtracting
94. When asked, reports trying relationships before scanning

Comment: All of these have near zero loadings on Factor 1 except Variables 88 and 93, which have loadings around .20. These two variables have moderate correlations with Mathematics, Number Series, Vocabulary, and Reading tests, and College vs. High School.

Loadings on Factor 3: COLLEGE .15, SUR -.05, VOC .20, NUM .36, MAT .26, MAR -.02, LET .02

Few relationships, N = 94

| A | B | C | D |
|---|---|---|---|
| SUR .71 | REA .71 | NUM .58 | MAR .49 |
| CAR .51 | VOC .64 | MAT .48 | CON .26 |
| PUN .38 | VER .60 | SPA -.24 | SPA .24 |
| CUB .37 | SPA .32 | CUB -.23 | SHI .23 |
| FIG .32 | (NUM -.13) | LET .21 | LET .23 |
| CON .32 | | | (NUM .09) |
| SPA .23 | | | |
| (NUM -.15) | | | |

| E |
|---|
| LET .40 |
| PUN -.24 |
| (NUM .04) |

| | A | B | C |
|---|---|---|---|
| B | .49 | | |
| C | .60 | .68 | |
| D | .73 | .53 | .64 |

| | M. | S.D. |
|---|---|---|
| SUR | 26.5 | 12.5 |
| VOC | 20.7 | 8.6 |
| NUM | 23.1 | 4.5 |
| MAR | 9.5 | 3.8 |
| LET | 14.5 | 3.7 |
| MAT | 11.5 | 3.3 |

Many relationships, N = 83

| A | B | C | D |
|---|---|---|---|
| SUR .84 | VOC .76 | NUM .63 | MAR .56 |
| CAR .72 | VER .56 | LET .34 | SHI .34 |
| CON .55 | REA .56 | MAT .29 | (NUM -.03) |
| CUB .55 | MAT .25 | | |
| PUN .52 | CUB .20 | | |
| FIG .49 | (NUM -.10) | | |
| SPA .49 | | | |
| LET .21 | | | |
| (NUM -.06) | | | |

| E |
|---|
| LET .38 |
| CON .36 |
| CUB .24 |
| SPA -.21 |
| (NUM .01) |

| | A | B | C |
|---|---|---|---|
| B | .34 | | |
| C | .47 | .64 | |
| D | .55 | .64 | .71 |

| | M. | S.D. |
|---|---|---|
| SUR | 29.7 | 13.7 |
| VOC | 24.3 | 7.2 |
| NUM | 26.4 | 3.7 |
| MAR | 9.6 | 3.9 |
| LET | 15.6 | 4.0 |
| MAT | 13.1 | 2.6 |

## Pair 4 - Likes Verbal Subjects vs. Likes Science

Subjects who did not check science as their favorite subject or major. Variable 107, Science as favorite subject or major, has a loading of -.85 on Factor 4.

Loadings on Factor 4: COLLEGE .56, SUR -.20, VOC .50, NUM .06, MAT -.02, MAR -.09 LET -.12

| Likes science, N = 76 | | | | | Likes verbal subjects, N = 101 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | A | B | C | D | E |
| SUR .78 | VOC .57 | NUM .58 | MAR .65 | FIG .35 | SUR .75 | VOC .65 | NUM .69 | SHI .38 | LET .41 |
| CAR .72 | REA .54 | MAT .25 | SHI .42 | CON .21 | CAR .54 | REA .61 | MAT .38 | MAR .35 | |
| CUB .54 | VER .47 | LET .20 | FIG .21 | | SPA .49 | VER .53 | LET .25 | CON .24 | |
| CON .51 | MAT .25 | | | | PUN .43 | CUB .33 | | | |
| PUN .43 | PUN .21 | | | | FIG .42 | | | | |
| FIG .38 | | | | | CUB .39 | | | | |
| LET .27 | | | | | CON .36 | | | | |
| SPA .26 | | | | | | | | | |

| Likes science | A | B | C | Likes verbal subjects | A | B | C |
|---|---|---|---|---|---|---|---|
| B | .51 | | | B | .49 | | |
| C | .40 | .80 | | C | .49 | .63 | |
| D | .51 | .62 | .56 | D | .69 | .70 | .70 |

| Likes science | M. | S.D. | Likes verbal subjects | M. | S.D. |
|---|---|---|---|---|---|
| SUR | 29.9 | 13.1 | SUR | 26.5 | 12.9 |
| VOC | 19.9 | 8.1 | VOC | 24.3 | 7.8 |
| NUM | 25.3 | 3.7 | NUM | 24.2 | 4.9 |
| MAR | 10.0 | 3.7 | MAR | 9.2 | 3.9 |
| LET | 15.2 | 4.0 | LET | 14.8 | 3.7 |
| MAT | 12.3 | 3.3 | MAT | 12.2 | 3.0 |

## Pair 5 - Uses Hypotheses for Letter Groups Items

Subjects who were marked plus on 3 or more of the following:

25. Brings hypotheses to letter groups items rather than scans
26. Spends little time scanning
28. Applies hypotheses
31. When asked, reports starting with ideas rather than scanning
32. When asked, reports spending more time on ideas than on scanning

Loadings on Factor 5: COLLEGE .04, SUR -.03, VOC .09, NUM -.02, MAT .20, MAR -.30, LET -.27

| Scans, N = 110 | | | | Uses hypotheses, N = 67 | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | A | B | C | D |
| SUR .85 | VOC .72 | NUM .64 | MAR .63 | SUR .61 | VER .62 | NUM .54 | MAR .43 |
| CUB .59 | VER .64 | MAT .36 | SHI .33 | CAR .60 | REA .57 | MAT .52 | PUN .27 |
| CAR .57 | REA .64 | CUB-.30 | (LET .13) | CON .43 | VOC .56 | LET .32 | FIG .24 |
| FIG .47 | MAT .28 | LET .26 | | SPA .40 | (LET .13) | | SHI .22 |
| CON .44 | SHI .21 | | | PUN .30 | | E | (LET-.14) |
| PUN .42 | (LET .01) | E | | CUB .23 | | LET .54 | |
| SPA .35 | | LET .34 | | FIG .21 | | CUB .33 | |
| (LET .13) | | PUN-.21 | | (LET .13) | | CON .23 | |
| | | SPA-.21 | | | | VER-.21 | |

| | A | B | C | | A | B | C |
|---|---|---|---|---|---|---|---|
| B | .45 | | | B | .39 | | |
| C | .57 | .65 | | C | .52 | .74 | |
| D | .61 | .58 | .61 | D | .76 | .57 | .69 |

| | M. | S.D. | | M. | S.D. |
|---|---|---|---|---|---|
| SUR | 28.3 | 13.3 | SUR | 27.4 | 12.8 |
| VOC | 22.8 | 7.9 | VOC | 21.7 | 8.6 |
| NUM | 24.7 | 4.3 | NUM | 24.5 | 4.7 |
| MAR | 9.8 | 4.0 | MAR | 9.1 | 3.6 |
| LET | 15.3 | 3.8 | LET | 14.5 | 4.0 |
| MAT | 12.2 | 3.0 | MAT | 12.3 | 3.3 |

## Pair 6 - Uses Hypotheses for Marks Items

Subjects who were marked plus on 3 or more of the following:

96. Brings hypotheses to Marks items rather than scans
97. Spends little time scanning
99. Applies hypotheses
102. When asked, reports starting with ideas rather than scanning
103. When asked, reports spending more time on ideas than on scanning

Loadings on Factor 6: COLLEGE -.16, SUR .20, VOC -.29, NUM -.24, MAT -.30, MAR -.00, LET -.15

| Scans, N = 84 | | | | | Uses hypotheses, N = 93 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | A | B | C | D | E |
| SUR .81 | VER .67 | NUM .67 | MAR .62 | MAT-.33 | SUR .77 | VOC .62 | NUM .60 | MAR .52 | LET .49 |
| CAR .55 | VOC .62 | MAT .37 | SHI .42 | LET .31 | CAR .56 | REA .62 | MAT .39 | CON .20 | CUB .34 |
| CUB .52 | REA .54 | LET .35 | CON .20 | CUB .25 | SPA 55 | VER .57 | SHI .29 | | (MAR-.00) |
| PUN .50 | SPA .25 | CUB-.25 | | (MAR .04) | FIG .48 | MAT .20 | LET .21 | | |
| CON .41 | MAT .23 | (MAR .02) | | | CON .47 | (MAR-.02) | (MAR .02) | | |
| FIG .39 | (MAR-.11) | | | | CUB .43 | | | | |
| SPA .32 | | | | | PUN .37 | | | | |
| (MAR-.11) | | | | | SHI .26 | | | | |
| | | | | | (MAR-.12) | | | | |

Scans, N = 84

| | A | B | C |
|---|---|---|---|
| B | .43 | | |
| C | .55 | .63 | |
| D | .56 | .66 | .57 |

Uses hypotheses, N = 93

| | A | B | C |
|---|---|---|---|
| B | .41 | | |
| C | .46 | .72 | |
| D | .66 | .37 | .55 |

Scans, N = 84

| | M. | S.D. |
|---|---|---|
| SUR | 28.4 | 13.3 |
| VOC | 23.0 | 8.2 |
| NUM | 25.0 | 4.3 |
| MAR | 9.1 | 3.8 |
| LET | 15.4 | 4.2 |
| MAT | 12.5 | 2.8 |

Uses hypotheses, N = 93

| | M. | S.D. |
|---|---|---|
| SUR | 27.6 | 13.0 |
| VOC | 21.8 | 8.1 |
| NUM | 24.3 | 4.6 |
| MAR | 9.9 | 3.9 |
| LET | 14.7 | 3.4 |
| MAT | 12.1 | 3.3 |

### Pair 7 - Uses Reasoning for Spatial Orientation Items

Subjects who were marked plus on 3 or more of the following:

78. Has a mechanical rule for resolving tilt of boat
79. Uses geometrical terms
80. Uses few visualization indications
83. When asked, reports he uses rule for resolving tilt
84. When asked, reports he uses geometry

Loadings on Factor 7: COLLEGE -.15, SUR .04, VOC .10, NUM .08, MAT .07, MAR -.00, LET .06, SPA .03

Uses visualization, N = 88

| A | B | C | D |
|---|---|---|---|
| SUR .82 | VOC .58 | NUM .74 | MAR .40 |
| CAR .62 | VER .51 | MAT .34 | SHI .38 |
| CON .53 | REA .50 | LET .32 | (SPA-.03) |
| CUB .50 | MAT .22 | (SPA .00) | |
| PUN .49 | (SPA .17) | | |
| FIG .48 | | | |
| SPA .42 | | | |
| LET .21 | | | |

| E |
|---|
| LET .45 |
| CON .25 |
| SPA-.23 |

| | A | B | C |
|---|---|---|---|
| B | .49 | | |
| C | .54 | .58 | |
| D | .64 | .79 | .05 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.5 | 14.2 |
| VOC | 21.9 | 7.8 |
| NUM | 24.2 | 4.6 |
| MAR | 9.3 | 3.9 |
| LET | 14.9 | 3.8 |
| MAT | 12.0 | 3.3 |
| SPA | 25.7 | 13.1 |

Uses reason, N = 89

| A | B | C | D |
|---|---|---|---|
| SUR .75 | VOC .64 | NUM .52 | MAR .56 |
| CAR .56 | REA .57 | MAT .46 | CON .33 |
| CUB .59 | VER .51 | SHI .31 | SPA .31 |
| FIG .30 | SPA .28 | (SPA-.17) | PUN .29 |
| CON .30 | | | FIG .26 |
| SPA .29 | | | SHI .22 |
| PUN .28 | | | LET .20 |

| E |
|---|
| PUN .40 |
| MAT .24 |
| CON .22 |
| LET-.20 |
| (SPA-.19) |

| | A | B | C |
|---|---|---|---|
| B | .32 | | |
| C | .45 | .72 | |
| D | .62 | .22 | .53 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.4 | 12.0 |
| VOC | 22.9 | 8.6 |
| NUM | 25.1 | 4.2 |
| MAR | 9.8 | 3.8 |
| LET | 15.1 | 3.9 |
| MAT | 12.5 | 2.9 |
| SPA | 26.1 | 10.5 |

## Pair 8 - Uses Details of Figures in Concealed Figures Items

Subjects who were marked plus on 2 or more of the following:

71. Uses a specific characteristic for deciding an item does not contain figure
72. Accepts presence of figure in item part by part
77. When asked, reports accepting presence of figure part by part

Loadings on Factor 8: COLLEGE .13, SUR -.20, VOC -.01, NUM .01, MAT -.12, MAR .16, LET .06, CON -.05

Does not use details, N = 81

| A | B | C | D |
|---|---|---|---|
| SUR .73 | VER .68 | NUM .65 | MAR .64 |
| CAR .45 | VOC .63 | MAT .36 | SHI .31 |
| CON .40 | REA .58 | LET .35 | (CON .06) |
| FIG .39 | MAT 28 | CUB-.23 | |
| PUN .39 | (CON .02) | (CON .04) | |
| CUB .38 | | | |
| SPA .37 | | | |

| E |
|---|
| MAT .31 |
| LET-.31 |
| PUN .21 |
| (CON .06) |

| | A | B | C |
|---|---|---|---|
| B | .59 | | |
| C | .66 | .69 | |
| D | .73 | .64 | .64 |

| | M. | S.D. |
|---|---|---|
| SUR | 30.7 | 14.3 |
| VOC | 21.6 | 8.5 |
| NUM | 24.3 | 4.5 |
| MAR | 9.2 | 4.1 |
| LET | 14.5 | 3.7 |
| MAT | 12.3 | 3.3 |
| CON | 72.1 | 22.2 |

Uses details, N = 96

| A | B | C | D |
|---|---|---|---|
| SUR .80 | VOC .71 | MAT .54 | MAR .38 |
| CAR .66 | REA .64 | NUM .48 | SHI .32 |
| CUB .58 | VER .55 | LET .21 | FIG .31 |
| PUN .46 | (CON .03) | (CON-.06) | CUB-.20 |
| CON .45 | | | (CON .19) |
| FIG .34 | | | |
| SPA .34 | | | |
| LET .23 | | | |

| E |
|---|
| LET .51 |
| CUB .30 |
| FIG .28 |
| (CON .17) |

| | A | B | C |
|---|---|---|---|
| B | .28 | | |
| C | .42 | .67 | |
| D | .59 | .55 | .71 |

| | M. | S.D. |
|---|---|---|
| SUR | 25.6 | 11.6 |
| VOC | 23.0 | 7.9 |
| NUM | 24.9 | 4.4 |
| MAR | 9.9 | 3.5 |
| LET | 15.4 | 3.9 |
| MAT | 12.3 | 2.9 |
| CON | 69.6 | 19.2 |

Pair 9 - Considers Each Reading Item Alternative

Subjects who were checked as tentatively rejecting or accepting each alternative of the Reading Test items before reaching a decision.

Loadings on Factor 9: COLLEGE .04, SUR -.10, VOC -.02, NUM .11, MAT -.01,
MAR -.17, LET .06, REA .08

| Does not consider each, N = 83 | | | | Considers each alternative, N = 94 | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | A | B | C | D |
| SUR .77 | REA .73 | NUM .66 | MAR .58 | SUR .80 | VOC .65 | NUM .54 | MAR .49 |
| CUB .48 | VOC .72 | MAT .46 | SHI .29 | CAR .67 | VER .50 | MAT .30 | SHI .36 |
| CAR .45 | VER .63 | LET .21 | (REA .03) | CUB .43 | REA .42 | LET .27 | CON .24 |
| CON .43 | SPA .37 | CUB-.20 | | SPA .41 | | (REA .04) | PUN .23 |
| FIG .40 | MAT .23 | (REA-.11) | | PUN .40 | | | SPA .23 |
| PUN .37 | CUB .20 | | | FIG .37 | | E | FIG .20 |
| SPA .31 | | E | | CON .35 | | LET .59 | (REA .01) |
| (REA .03) | | CUB .36 | | (REA .04) | | FIG .24 | |
| | | PUN-.23 | | | | CUB .23 | |
| | | LET .22 | | | | CON .20 | |
| | | (REA-.04) | | | | (REA .03) | |

| | A | B | C | | A | B | C |
|---|---|---|---|---|---|---|---|
| B | .47 | | | B | .41 | | |
| C | .67 | .60 | | C | .33 | .80 | |
| D | .73 | .57 | .67 | D | .58 | .63 | .63 |

| | M. | S.D. | | M. | S.D. |
|---|---|---|---|---|---|
| SUR | 28.2 | 13.9 | SUR | 27.8 | 12.4 |
| VOC | 23.2 | 8.5 | VOC | 21.7 | 7.9 |
| NUM | 24.9 | 4.3 | NUM | 24.4 | 4.6 |
| MAR | 9.8 | 3.8 | MAR | 9.4 | 3.9 |
| LET | 15.1 | 3.7 | LET | 14.9 | 4.0 |
| MAT | 12.3 | 3.2 | MAT | 12.2 | 3.0 |
| REA | 10.1 | 3.6 | REA | 9.9 | 3.3 |

## Pair 11 - Studies Relationships in Verbal Analogies Items

Students who were marked plus on 2 or more of the following:

44. Systematically evaluates alternatives in Verbal Analogies items
46. When asked, reports applying relationship of stem to each alternative rather than scanning the alternatives to find one that looks right
47. When asked, reports spending more time studying relationships than scanning

Comment: Correlations with College vs. High School and the test scores including Verbal Analogies are generally low and positive for Variable 44, mixed for 46, and substantially negative for 47.

Loadings on Factor 11: COLLEGE -.03, SUR -.13, VOC .03, NUM .21, MAT .00, MAR -.06, LET .16, VER -.02

Scans, N = 81

| A | B | C | D |
|---|---|---|---|
| SUR .76 | VOC .74 | NUM .67 | MAR .61 |
| PUN .61 | VER .63 | CUB -.28 | SHI .40 |
| CUB .61 | REA .63 | MAT .28 | (VER -.01) |
| CAR .52 | MAT .28 | LET .24 | |
| CON .47 | SPA .23 | (VER -.01) | |
| FIG .42 | | | |
| SPA .40 | | | |
| (VER .01) | | | |

| E |
|---|
| LET .47 |
| SPA -.28 |
| CUB .23 |
| (VER -.11) |

| | A | B | C |
|---|---|---|---|
| B | .44 | | |
| C | .57 | .63 | |
| D | .50 | .57 | .57 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.0 | 13.4 |
| VOC | 23.5 | 8.4 |
| NUM | 24.7 | 4.3 |
| MAR | 9.6 | 4.0 |
| LET | 15.2 | 3.7 |
| MAT | 12.5 | 2.9 |
| VER | 8.9 | 3.7 |

Studies relationships, N = 96

| A | B | C | D |
|---|---|---|---|
| SUR .78 | VOC .65 | NUM .62 | MAR .54 |
| CAR .60 | REA .63 | MAT .49 | PUN .28 |
| FIG .36 | VER .58 | LET .24 | CON .23 |
| SPA .34 | | (VER -.02) | (VER -.02) |
| CON .33 | | | |
| CUB .33 | | | |
| PUN .25 | | | |
| (VER .04) | | | |

| E |
|---|
| LET .35 |
| FIG .32 |
| CUB .30 |
| SPA .24 |
| (VER -.02) |

| | A | B | C |
|---|---|---|---|
| B | .41 | | |
| C | .48 | .71 | |
| D | .73 | .56 | .65 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.9 | 12.9 |
| VOC | 21.5 | 7.9 |
| NUM | 24.6 | 4.6 |
| MAR | 9.5 | 3.7 |
| LET | 14.9 | 4.0 |
| MAT | 12.1 | 3.3 |
| VER | 8.3 | 3.6 |

## Pair 12 - Notes Points while Reading in the Reading Test

Subjects who were marked plus on 1 or both of the following:

61. Underlines or takes notes while reading the paragraph
67. When asked, reports mentally (or otherwise), noting particular points while reading

Comments: Variable 61 correlates .58 with College vs. High School, .39 with Vocabulary, .22 with Mathematics, low positive with most other tests, and .11 with Reading. Variable 67 correlates low negative with College vs. High School and the test scores, -.23 with Reading. Variables 61 and 67 correlate with each other .59.

Loadings on Factor 12: COLLEGE .24, SUR -.06, VOC .09, NUM -.08, MAT .11 MAR .19, LET -.13, REA -.09

Reads for general impression, N = 98

| A | B | C | D |
|---|---|---|---|
| SUR .74 | VER .57 | NUM .52 | MAR .54 |
| CUB .51 | VOC .57 | MAT .41 | SHI .29 |
| CAR .50 | REA .47 | (REA-.03) | SUR-.21 |
| PUN .47 | | | (REA .08) |
| CON .42 | | E | |
| FIG .42 | | LET .47 | |
| SPA .40 | | (REA-.04) | |
| (REA .03) | | | |

| | A | B | C |
|---|---|---|---|
| B | .52 | | |
| C | .59 | .77 | |
| D | .72 | .59 | .63 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.7 | 13.8 |
| VOC | 22.8 | 8.0 |
| NUM | 24.9 | 4.0 |
| MAR | 9.3 | 3.8 |
| LET | 15.1 | 3.9 |
| MAT | 12.4 | 3.0 |
| REA | 10.2 | 3.2 |

Notes points, N = 79

| A | B | C | D |
|---|---|---|---|
| SUR .83 | VOC .75 | NUM .69 | MAR .49 |
| CAR .66 | REA .74 | LET .44 | SHI .38 |
| CON .45 | VER .62 | MAT .41 | FIG .30 |
| PUN .38 | CUB .31 | SPA-.22 | SPA .29 |
| SPA .36 | MAT .27 | (REA-.05) | (REA-.04) |
| CUB .35 | | | |
| FIG .34 | | | E |
| (REA-.01) | | CUB .32 | MAT-.24 |
| | | FIG .27 | (REA .11) |
| | | LET .27 | |

| | A | B | C |
|---|---|---|---|
| B | .32 | | |
| C | .44 | .60 | |
| D | .55 | .62 | .69 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.1 | 12.2 |
| VOC | 21.9 | 8.4 |
| NUM | 24.3 | 4.9 |
| MAR | 9.9 | 3.8 |
| LET | 14.9 | 3.8 |
| MAT | 12.1 | 3.2 |
| REA | 9.8 | 3.7 |

## Pair 13 - Art or Music Activities

Subjects who listed activities on the questionnaire in one or both of the following categories:

113. Art or music activities at home
116. Art or music activities in school

Loadings on Factor 13: COLLEGE .11, SUR -.08, VOC .02, NUM .18, MAT .14, MAR -.02, LET .09, SHI .01

Neither of these, N = 105

| A | B | C | D |
|---|---|---|---|
| SUR .78 | VOC .72 | NUM .73 | MAR .54 |
| CAR .59 | REA .70 | MAT .42 | (SHI .19) |
| CON .46 | VER .68 | LET .23 | |
| PUN .39 | SPA .29 | (SHI .13) | |
| FIG .39 | MAT .28 | | |
| CUB .38 | CUB .26 | | |
| SPA .29 | SHI .23 | | |
| (SHI .06) | | | |

| E |
|---|
| CUB .44 |
| LET .43 |
| (SHI .02) |

| | A | B | C |
|---|---|---|---|
| B | .36 | | |
| C | .50 | .63 | |
| D | .67 | .51 | .58 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.8 | 12.8 |
| VOC | 21.6 | 8.5 |
| NUM | 24.1 | 4.5 |
| MAR | 9.4 | 3.6 |
| LET | 14.6 | 3.9 |
| MAT | 12.0 | 3.1 |
| SHI | 39.3 | 7.2 |

Art or music activities, N = 72

| A | B | C | D |
|---|---|---|---|
| SUR .80 | VOC .62 | NUM .58 | SHI .51 |
| CUB .62 | VER .50 | MAT .28 | MAR .48 |
| CAR .51 | REA .45 | LET .27 | CON .21 |
| SPA .50 | (SHI .08) | (SHI-.06) | |
| PUN .45 | | | |
| FIG .39 | | | |
| CON .39 | | | |
| (SHI .06) | | | |

| E |
|---|
| LET .43 |
| CON .33 |
| (SHI .02) |

| | A | B | C |
|---|---|---|---|
| B | .56 | | |
| C | .62 | .77 | |
| D | .66 | .67 | .70 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.3 | 13.6 |
| VOC | 23.5 | 7.6 |
| NUM | 25.5 | 4.2 |
| MAR | 9.7 | 4.1 |
| LET | 15.6 | 3.7 |
| MAT | 12.7 | 3.0 |
| SHI | 39.8 | 8.9 |

## Pair 14 - Few Visualization Indications

Subjects who were marked plus on 2 or more of the following:

14. Few visualization indications made in solving Cubes items
36. Few visualization indications made in solving Surface Development items
52. Few visualization indications made in solving Cards items

Comment: Intercorrelations of these 3 variables range from .27 to .52; those with Few Visualization indications for Punched Holes and Spatial Orientation are positive but below .25. For the 2 latter variables, respectively, the loadings on Factor 14 are .16 and .22 as compared with loadings of .37, .87, and .58, respectively, for Variables 14, 36, and 52.

Loadings on Factor 14: COLLEGE .10, SUR .06, VOC .08, NUM .02, MAT -.02, MAR .09, LET -.01, CUB -.00, CAR .14

Many visualization indications, N = 76

| A | B | C | D |
|---|---|---|---|
| SUR .71 | VOC .56 | NUM .64 | MAR .39 |
| CAR .62 | VER .51 | MAT .39 | SHI .35 |
| CUB .47 | REA .45 | LET .35 | FIG .27 |
| PUN .44 | LET .34 | | PUN .21 |
| CON .40 | | | |
| SPA .36 | | | |
| FIG .28 | | | |

| E | |
|---|---|
| LET .38 | FIG .24 |
| MAT-.29 | SPA .22 |

| | A | B | C |
|---|---|---|---|
| B | .51 | | |
| C | .45 | .64 | |
| D | .67 | .79 | .74 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.0 | 12.5 |
| VOC | 21.6 | 8.0 |
| NUM | 24.4 | 4.8 |
| MAR | 9.3 | 4.0 |
| LET | 14.6 | 3.8 |
| MAT | 12.1 | 3.4 |
| CUB | 13.1 | 8.0 |
| CAR | 65.8 | 21.0 |

Few visualization indications, N = 101

| A | B | C | D |
|---|---|---|---|
| SUR .79 | VER .67 | NUM .56 | MAR .57 |
| CAR .55 | VOC .67 | MAT .45 | SHI .31 |
| CON .45 | REA .62 | | SUR-.22 |
| CUB .43 | SHI .32 | | |
| FIG .41 | SPA .25 | | |
| PUN .34 | | | |
| SPA .33 | | | |
| LET .20 | | | |

| E |
|---|
| LET .37 |
| SPA-.35 |
| CON .20 |

| | A | B | C |
|---|---|---|---|
| B | .37 | | |
| C | .57 | .69 | |
| D | .67 | .36 | .48 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.7 | 13.6 |
| VOC | 23.0 | 8.3 |
| NUM | 24.8 | 4.2 |
| MAR | 9.7 | 3.7 |
| LET | 15.3 | 3.9 |
| MAT | 12.4 | 2.9 |
| CUB | 13.3 | 8.3 |
| CAR | 67.0 | 23.6 |

## Pair 15 - Analytic Approach to Cubes Items

Subjects who were marked plus on 2 or more of the following:

13. Geometrical terms used in solving Cubes items
14. Few visualization indications made in solving Cubes items
16. When asked, reports mentally rotating the cube on two separate axes

Loadings on Factor 15: COLLEGE .03, SUR -.14, VOC -.00, NUM .02, MAT .13, MAR -.01, LET .15, CUB -.03

Visual or other, N = 86

| A | B | C | D |
|---|---|---|---|
| SUR .76 | VOC .67 | NUM .76 | MAR .55 |
| CAR .60 | VER .63 | MAT .43 | SHI .24 |
| CUB .52 | REA .52 | LET .22 | SPA .23 |
| FIG .51 | MAT .20 | CUB-.20 | (CUB .01) |
| CON .50 | (CUB .11) | | |
| PUN .37 | | E | |
| SPA .28 | | LET .40 | |
| MAT .20 | | (CUB .15) | |

| | A | B | C |
|---|---|---|---|
| B | .63 | | |
| C | .46 | .54 | |
| D | .67 | .71 | .59 |

| | M. | S.D. |
|---|---|---|
| SUR | 29.0 | 14.1 |
| VOC | 22.0 | 8.5 |
| NUM | 24.5 | 4.5 |
| MAR | 9.1 | 3.7 |
| LET | 14.6 | 3.8 |
| MAT | 12.1 | 3.2 |
| CUB | 14.5 | 8.5 |

Analytic, N = 91

| A | B | C | D |
|---|---|---|---|
| SUR .64 | REA .75 | LET .52 | MAR .49 |
| CAR .46 | VOC .73 | NUM .29 | SHI .32 |
| PUN .35 | VER .66 | CUB .24 | CON .23 |
| SPA .35 | MAT .60 | VER-.24 | (CUB-.02) |
| CON .24 | NUM .44 | | |
| LET-.22 | (CUB .07) | E | |
| (CUB .07) | | SPA .35 | |
| | | (CUB .17) | |

| | A | B | C |
|---|---|---|---|
| B | .30 | | |
| C | .79 | .38 | |
| D | .61 | .60 | .73 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.0 | 12.1 |
| VOC | 22.7 | 7.9 |
| NUM | 24.8 | 4.4 |
| MAR | 10.0 | 3.9 |
| LET | 15.3 | 3.9 |
| MAT | 12.4 | 2.9 |
| CUB | 12.0 | 7.6 |

## Pair 16 - Geometrical Approach to Punched Holes and Surface Development

Subjects who were marked plus on 2 or more of the following:

19. Volunteers that he has a system for Punched Holes items
21. Few visualization indications made in solving Punched Holes items
37. Geometrical reasoning used in solving Surface Development items

Loadings on Factor 16: COLLEGE .02, SUR -.03, VOC -.04, NUM -.09, MAT -.08, MAR -.06, LET -.24, PUN .11

**Visual or other, N = 91**

| A | B | C | D | E |
|---|---|---|---|---|
| SUR .76 | VOC .70 | NUM .69 | MAR .47 | LET .45 |
| CAR .64 | REA .62 | MAT .44 | SHI .42 | (PUN-.07) |
| PUN .56 | VER .57 | LET .22 | (PUN .01) | (SUR-.06) |
| SPA .52 | MAT .24 | (PUN .07) | (SUR-.08) | |
| FIG .51 | SPA .22 | (SUR-.09) | | |
| CON .50 | CUB .21 | | | |
| CUB .46 | (PUN-.00) | | | |
| | (SUR .06) | | | |

| | A | B | C |
|---|---|---|---|
| B | .48 | | |
| C | .53 | .61 | |
| D | .60 | .70 | .65 |

| | M. | S.D. |
|---|---|---|
| SUR | 25.5 | 14.1 |
| VOC | 21.6 | 8.4 |
| NUM | 24.1 | 4.6 |
| MAR | 8.8 | 3.9 |
| LET | 14.6 | 4.0 |
| MAT | 11.7 | 3.4 |
| PUN | 42.4 | 18.6 |

**Geometric, N = 86**

| A | B | C | D | E |
|---|---|---|---|---|
| SUR .91 | REA .58 | NUM .55 | MAR .58 | LET .45 |
| CAR .52 | VOC .56 | MAT .30 | FIG .33 | CON .25 |
| CUB .47 | VER .51 | LET .30 | PUN .32 | CUB .24 |
| CON .40 | MAT .20 | SHI .26 | SPA .28 | (PUN-.06) |
| FIG .27 | (PUN .12) | (PUN-.08) | SHI .22 | (SUR-.04) |
| PUN .26 | (SUR .09) | (SUR-.16) | SUR-.20 | |
| SPA .20 | | | | |

| | A | B | C |
|---|---|---|---|
| B | .30 | | |
| C | .44 | .77 | |
| D | .55 | .30 | .48 |

| | M. | S.D. |
|---|---|---|
| SUR | 30.6 | 11.4 |
| VOC | 23.2 | 7.9 |
| NUM | 25.2 | 4.2 |
| MAR | 10.4 | 3.6 |
| LET | 15.4 | 3.6 |
| MAT | 12.9 | 2.6 |
| PUN | 53.4 | 12.6 |

Pair 17 - Can List Many Hypotheses for Letter Grouping and Marks Items

Subjects who were marked plus on 1 or both of the following:

33. When asked, was able to list many hypotheses on Letter Groups items
104. When asked, was able to list many hypotheses on Marks items

Comment: Variable 33 has near zero or low negative correlations with College vs. H.S. and the test scores. Its correlations are particularly negative for Letter Groups and Marks test scores. Variable 104 has moderate positive correlations with College vs. H.S. and all test scores. They correlate .45 with each other. Variable 104 has low correlations with the Marks test items listed for Pair 6.

Loadings on Factor 17: COLLEGE .03, SUR .00, VOC .22, NUM .21, MAT .00, MAR .12, LET .16

| Lists Few Hypotheses, N = 72 | | | |
|---|---|---|---|
| A | B | C | D |
| SUR .70 | VER .73 | NUM .67 | MAR .57 |
| CUB .50 | REA .54 | MAT .39 | SPA .27 |
| CON .47 | VOC .53 | LET .31 | (SHI .19) |
| CAR .45 | SPA .30 | CUB-.21 | (LET .01) |
| PUN .42 | CUB .23 | SPA-.21 | |
| FIG .31 | SHI .20 | (MAR .06) | |
| SPA .26 | FIG .20 | | |
| (LET .07) | (LET .13) | | E |
| (MAR-.10) | (MAR .01) | LET .42 | CAR .20 |
| | | CON .28 | (MAR-.00) |

| Lists Many Hypotheses, N = 105 | | | |
|---|---|---|---|
| A | B | C | D |
| SUR .84 | VOC .69 | NUM .60 | MAR .55 |
| CAR .63 | REA .61 | MAT .43 | SHI .25 |
| CON .51 | VER .48 | LET .24 | SUR-.20 |
| PUN .48 | (LET-.01) | (MAR-.06) | (LET .10) |
| FIG .47 | (MAR-.06) | | |
| SPA .45 | | E | |
| CUB .42 | | LET .41 | |
| (LET .10) | | CUB .28 | |
| (MAR-.12) | | (MAR .01) | |

Lists Few Hypotheses, N = 72

| | A | B | C |
|---|---|---|---|
| B | .56 | | |
| C | .65 | .68 | |
| D | .66 | .26 | .49 |

| | M. | S.D. |
|---|---|---|
| SUR | 26.6 | 13.8 |
| VOC | 21.9 | 7.8 |
| NUM | 24.9 | 4.1 |
| MAR | 9.1 | 4.1 |
| LET | 14.9 | 4.3 |
| MAT | 12.1 | 2.9 |

Lists Many Hypotheses, N = 105

| | A | B | C |
|---|---|---|---|
| B | .36 | | |
| C | .50 | .72 | |
| D | .58 | .66 | .72 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.9 | 12.6 |
| VOC | 22.7 | 8.5 |
| NUM | 24.5 | 4.7 |
| MAR | 9.8 | 3.6 |
| LET | 15.0 | 3.5 |
| MAT | 12.4 | 3.2 |

Pair 20 - Faster Rejectance than Acceptance of Concealed Figures Items

Subjects who were marked plus on 1 or both of the following:

70. Decides an item does not contain a figure faster than that it does contain a figure
76. When asked, reports behavior in Variable 70

Loadings on Factor 20· COLLEGE .13, SUR-.19, VOC .09, NUM .33, MAT .26, MAR .11, LET-.13, CON-.07

| Faster acceptance, N = 53 | | | | Faster rejectance, N = 124 | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | A | B | C | D |
| SUR .75 | VER .62 | NUM .59 | MAR .63 | SUR .76 | VOC .68 | NUM .68 | MAR .49 |
| CAR .60 | REA .61 | MAT .42 | SHI .36 | CAR .50 | REA .64 | MAT .37 | SHI .31 |
| FIG .57 | VOC .61 | CUB-.25 | CUB .27 | CUB .44 | VER .59 | LET .28 | FIG .28 |
| SPA .53 | (CON .10) | (CON-.04) | (CON .11) | CON .33 | MAT .27 | (CON-.05) | SUR-.20 |
| CUB .53 | | | | PUN .33 | (CON-.02) | | PUN .20 |
| CON .48 | | E | | SPA .32 | | E | (CON .19) |
| PUN .47 | | LET .40 | | FIG .22 | | LET .48 | |
| | | CAR .26 | | | | CUB .38 | |
| | | SHI-.22 | | | | (CON .15) | |
| | | CUB-.20 | | | | | |
| | | (CON .15) | | | | | |

Faster acceptance, N = 53:

| | A | B | C |
|---|---|---|---|
| B | .58 | | |
| C | .60 | .74 | |
| D | .48 | .48 | .54 |

| | M. | S.D. |
|---|---|---|
| SUR | 28.8 | 13.0 |
| VOC | 21.4 | 8.9 |
| NUM | 23.7 | 4.8 |
| MAR | 8.5 | 4.2 |
| LET | 14.7 | 3.8 |
| MAT | 12.2 | 3.0 |
| CON | 70.2 | 21.4 |

Faster rejectance, N = 124:

| | A | B | C |
|---|---|---|---|
| B | .36 | | |
| C | .50 | .64 | |
| D | .75 | .58 | .66 |

| | M. | S.D. |
|---|---|---|
| SUR | 27.6 | 13.2 |
| VOC | 22.8 | 7.9 |
| NUM | 25.0 | 4.2 |
| MAR | 10.0 | 3.6 |
| LET | 15.1 | 3.9 |
| MAT | 12.3 | 3.1 |
| CON | 71.0 | 20.3 |

# References

Balinsky, B. An analysis of the mental factors of various age groups from nine to sixty. Genet. Psychol. Monogr., 1941, 23, 191-234.

Bloom, B. S., & Broder, L. J. Problem-solving processes of college students. Chicago: Univer. Chicago Press, 1950.

French, J. W. The description of aptitude and achievement tests in terms of rotated factors. Psychometric Monogr. No. 5, 1951.

French, J. W. The factorial invariance of pure-factor tests. J. educ. Psychol., 1957, 48, 93-109.

Frick, J. W., Guilford, J. P., Christensen, P. R., & Merrifield, P. R. A factor-analytic study of flexibility in thinking. Educ. psychol. Measmt, 1959, 19, 469-496.

Gardner, R. W. Cognitive controls of attention deployment as determinants of visual illusions. J. abnorm. soc. Psychol., 1961, 62, 120-127.

Gardner, R. W., Holzman, P. S., Klein, G. S., Linton, Harriet, & Spence, D. R. Cognitive control. Psychol. Issues, 1959, 1, No. 4.

Gardner, R. W., Jackson, D. N., & Messick, S. Personality organization in cognitive controls and intellectual abilities. Psychol. Issues, 1960, 2, Monogr. 8.

Gardner, R. W., & Long, R. I. Control, defence and centration effect: a study of scanning behaviour. Brit. J. Psychol., 1962, 53, 129-140.

Green, R. F., Guilford, J. P., Christensen, P. R., & Comrey, A. L. A factor-analytic study of reasoning abilities. Psychometrika, 1953, 18, 135-160.

Lucas, C. M. Analysis of the Relative Movement Test by a method of individual interviews. Research Bulletin 53-4. Princeton, N. J.: Educational Testing Service, 1953. (Multilithed report.)

Saunders, D. R. Moderator variables in prediction. _Educ. psychol. Measmt_, 1956, _16_, 209-222.

Thurstone, L. L. _Multiple-factor analysis_. Chicago: Univer. Chicago Press, 1947.

Witkin, H. A., Dyk, R. B., Faterson, Hanna F., Goodenough, D. R., & Karp, S. A. _Psychological differentiation_. New York: Wiley, 1962.

Witkin, H. A., Lewis, Helen B., Hertzman, M., Machover, Karen, Meissner, Pearl B., & Wapner, S. _Personality through perception_. New York: Harpers, 1954.

## Footnotes

[1] Grateful acknowledgment is made to Mr. Leighton A. Price, who skillfully and conscientiously conducted over 200 interviews, scheduled the testing, and helped in assembling the data used in this research.

[2] All computations were programmed and carried out by Dr. David R. Saunders.

[3] Specifically, there is almost always a sharp drop after the fifth eigenvalue. For the whole group, the first seven and last eigenvalues were as follows: 6.43, 1.60, .69, .39, .28, .11, .09 ... -.15. Out of the 34 subsample factorizations, only in the case of Pair 4-positive (liked verbal subjects) and Pair 12-positive (notes points while reading) was the drop in eigenvalue greater between the sixth and seventh factor than between the fifth and sixth. Compared to the last eigenvalue, the fifth was always higher and the sixth was lower in 20 out of 34 cases. Only in the case of Pair 12-positive was the sixth eigenvalue more than a quarter of the distance from the last one up to the fifth.

[4] Again the computations were devised, programmed, and carried out by Dr. David R. Saunders.

# APPENDIX A

## Interview Test Items

## MATH PROBLEMS

Directions: The 5 problems given below are similar to the ones which you did in the MATH PROBLEMS test. Work each problem. Then look at the five suggested answers and circle the letter corresponding to the correct answer.

1. Brown and Smith each placed a $10,000 order with a certain company. Brown was granted a discount of 20% and Smith was granted two successive discounts of 10% each. How much more did Smith pay than Brown?

   A No more
   B $100
   C $400
   D $1000
   E $1900

2. If eight persons each write an odd number less than 10 on a blackboard and no one number is written by more than three persons, what is the smallest possible sum of these numbers?

   A 16
   B 17
   C 22
   D 30
   E 34

3. A child's rectangular block measures 8 inches by 4 inches by 2 inches. What is the smallest number of these blocks needed to build a perfect cube?

   A 4
   B 8
   C 16
   D 32
   E 64

4. If Dick, who is cycling at 9 mph, starts 1 hour after Tom, who is walking at 4 mph, how many miles must he ride to catch up with Tom?

   A 3 1/5
   B 5 7/9
   C 7 1/5
   D 8 1/2
   E 16 1/5

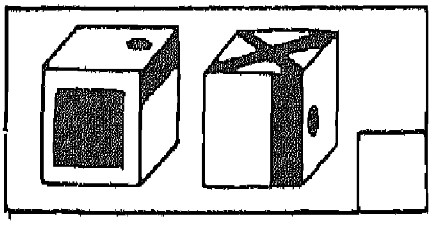
5. How much will it cost to erect a fence around a rectangular lot 40 feet long and 25 feet wide with fencing that costs 30 cents a foot?

   A $10
   B $13
   C $19.50
   D $30
   E $39

# CUBES

Directions: The 4 sets of drawings below are similar to the ones you did in the CUBES test. For each set put a plus (+) in the small square at the right if both drawings represent the same cube. Put a minus (-) in the square if they represent different cubes.

1.



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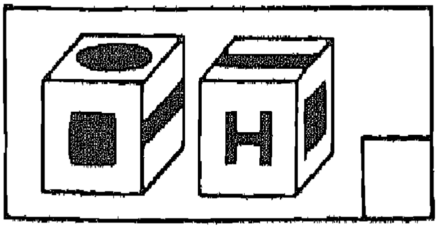

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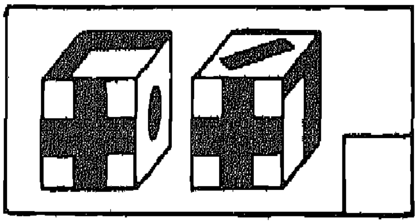
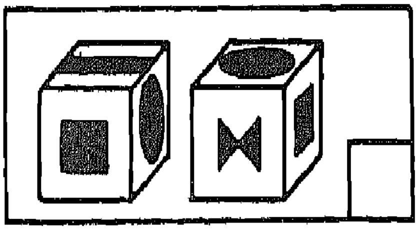


4.

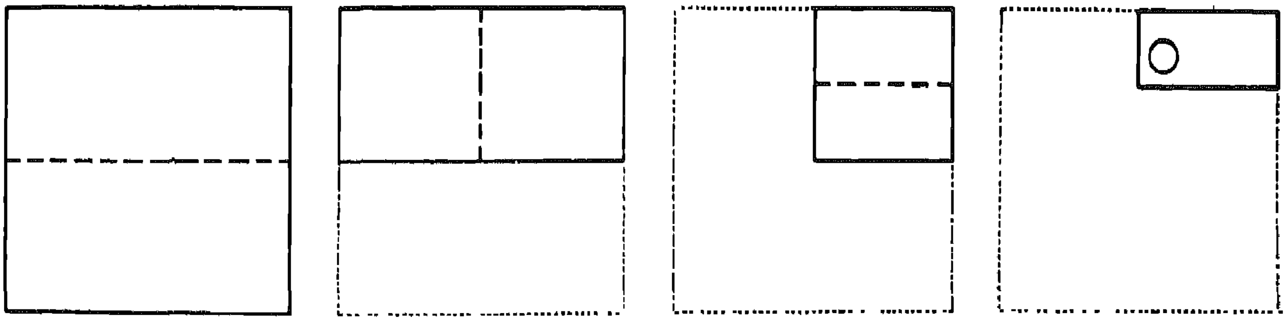


## PUNCHED HOLES

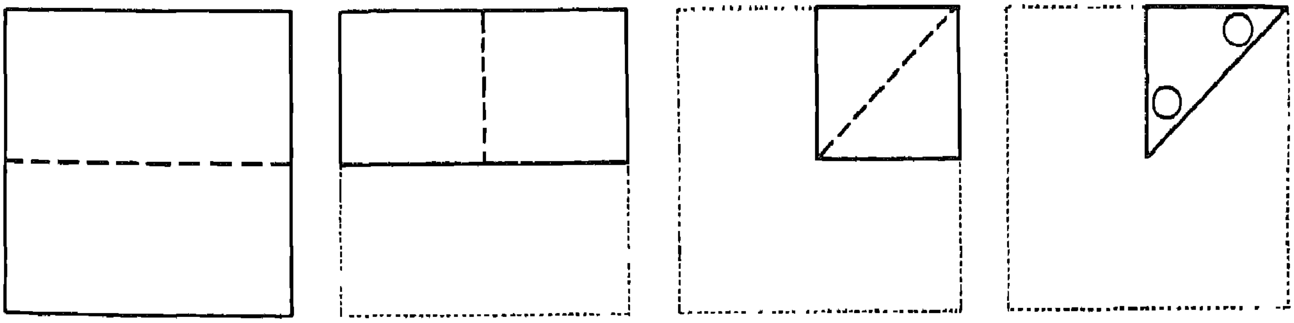
Directions: The 2 sets of diagrams below are similar to the ones that you did in the PUNCHED HOLES test. The diagrams represent a sheet of paper that is folded a number of times. Holes have been punched in the right hand diagram. Show by drawing small circles in the left square where the holes will be when the paper is unfolded.

If you think it will be helpful you may draw circles in the other figures, but do not do so if it will merely waste time.

1.



2.



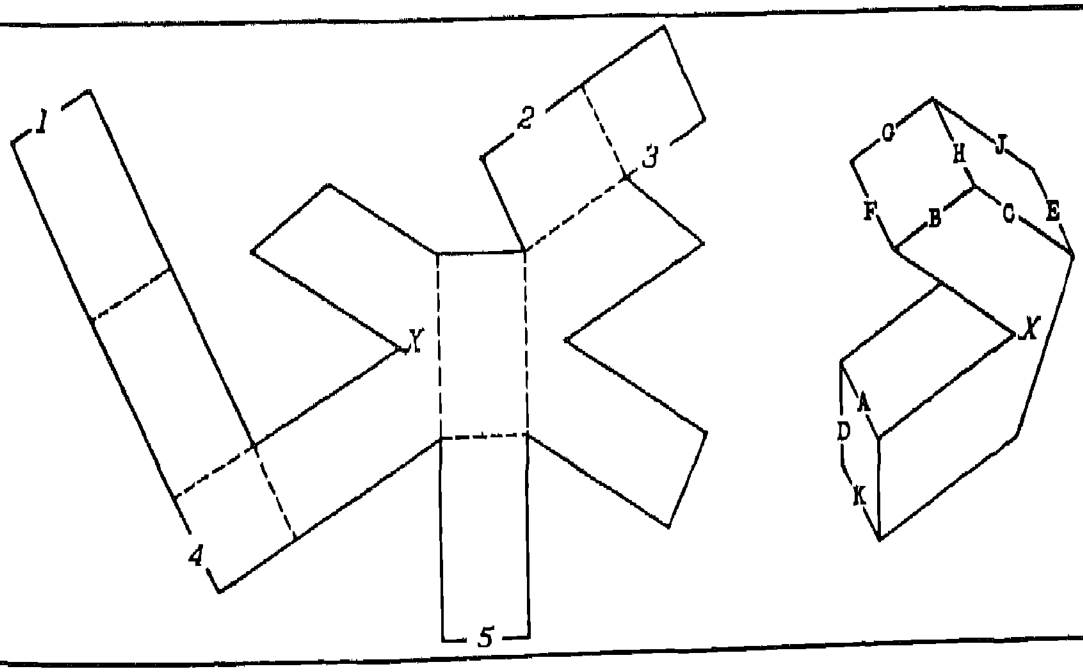
## LETTER GROUPING

Directions: The 5 rows of grouped letters given below are similar to the ones you did in the LETTER GROUPING test. In each row, three of the groups of letters are alike in some way. Circle the one that is different.

1. NNOP QRSS TTUV WWXY
2. PXAM SPCD DXMF SAMY
3. MBAN ODCP QFER SGHT
4. MLLM DCCD RSSR HGGH
5. STTT RRRS SSST QRRR

# SURFACE DEVELOPMENT

Directions: The problem below is similar to the ones you did in the SURFACE DEVELOPMENT test. The drawing on the left is a flat piece which can be folded on the dotted lines to form the solid figure on the right. If this is done, where will the edges and side marked by the numbers be in the solid figure? Remember that side X is always marked in both drawings.



|   |   |
|---|---|
| 1 |   |
| 2 |   |
| 3 |   |
| 4 |   |
| 5 |   |

## VERBAL ANALOGIES

Directions: The 4 items given below are similar to the ones which you did in the VERBAL ANALOGIES test. For each item circle the number of the pair of words which is related in the same way as the words of the original pair are related.

1. Small:Magnify::
    1 right:rectify
    2 loud:amplify
    3 indignant:pacify
    4 wise:stupefy
    5 obscure:clarify

2. Eulogy:Hear::
    1 elegy:flute
    2 monument:see
    3 trilogy:three
    4 shroud:mystery
    5 eyeglasses:face

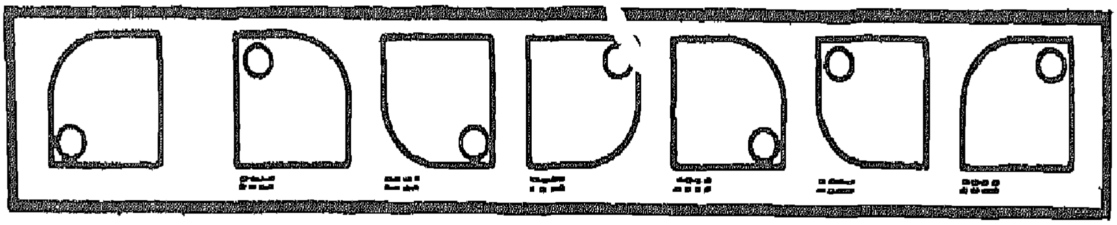
3. Systematic:Procedure::
    1 logical:argument
    2 timely:report
    3 intense:feeling
    4 practical:decision
    5 wary:opposition

4. Worldly:Body::
    1 valuable:gold
    2 celestial:Mars
    3 ethereal:spirit
    4 wordy:reminiscence
    5 round:solid

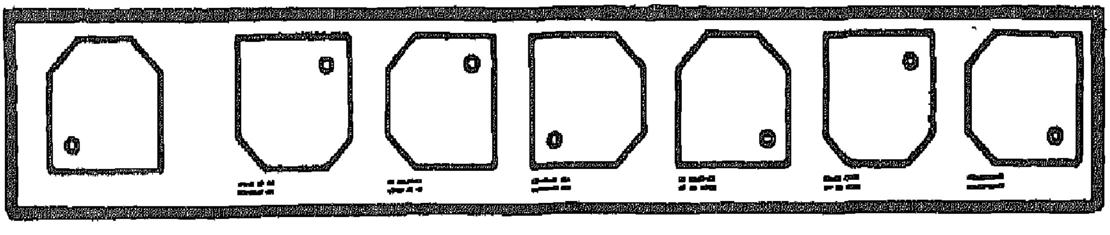
## CARDS

Directions: The 2 rows of cards shown below are similar to the ones which you did in the CARDS test. In each row, mark the space below every card that is like the first card in the row.

1.



2.



## READING

Directions: The selection given below is similar to the ones which you read in the READING test. Following the selection are several multiple choice items concerning it.

Read the selection carefully first, and then answer the multiple choice questions. Circle the number corresponding to the answer you select.

Beckmann forcefully expresses his misguided opinion of the ugliness of family life in a picture which might more appropriately be called "Wallowing in the Family." The effect is largely attained by his placement of the figures and by what may be termed the literary elements in his picture, such as the complete self-absorption and utter indifference to each other of the members of the family who are shown. But the more formal elements of color and design and drawing are also effective in creating the total impression. The dominance of the angular motif in the design and the cold inharmonious colors, coarsely laid on, heighten the expression of the artist's intensely disagreeable conception of family life. The distortion of the figures and the peculiar perspective work to the same end. By the piling up of such effects the picture achieves powerful expression.

1. Beckmann regards family life as

   1 uninteresting.
   2 stimulating.
   3 distasteful.
   4 amusing.
   5 beautiful.

2. The writer's attitude toward Beckmann's view of family life is one of

   1 agreement.
   2 disagreement.
   3 indignation.
   4 surprise.
   5 amusement.

3. The color and design of the painting reinforce its general effect because of their

   1 beauty.
   2 boldness.
   3 harshness.
   4 intensity.
   5 gracefulness.

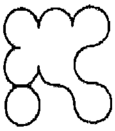
4. The lines in this painting tend to take the form of

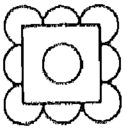
   1 sharp angles.
   2 gentle curves.
   3 twisting curves.
   4 slanted lines.
   5 disagreeable figures.

# CONCEALED FIGURES

Directions: The 5 rows of designs below are similar to the ones you did in the CONCEALED FIGURES test. In every row of designs the figure is concealed in at least one drawing and may be in as many as all four. Put a plus (+) in the parentheses below a drawing if it contains the figure. Put a minus (-) in the parentheses below a drawing if it does not contain the figure.

1.





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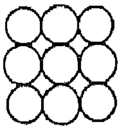

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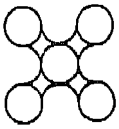

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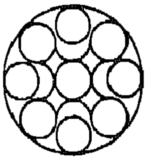

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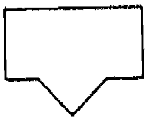

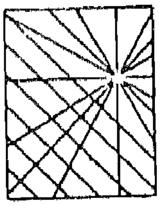

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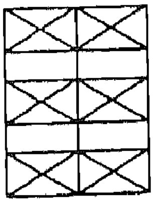

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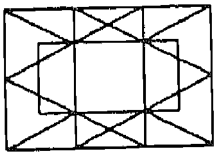

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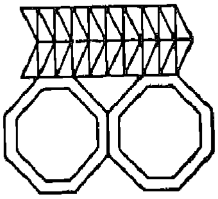

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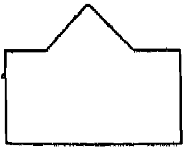

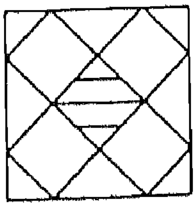

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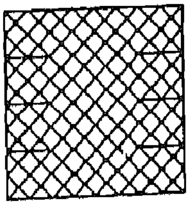

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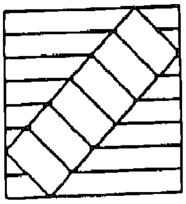

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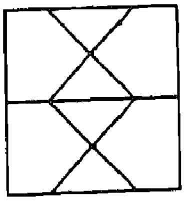

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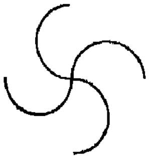

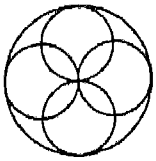

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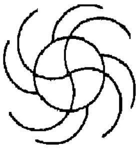

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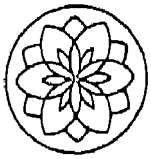

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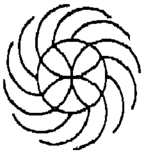

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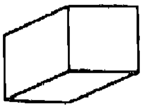

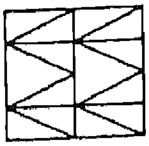

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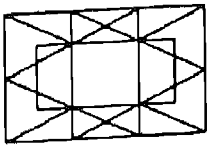

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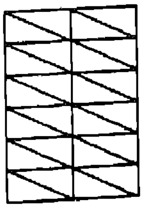
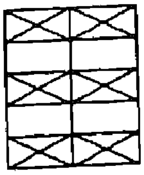


( )

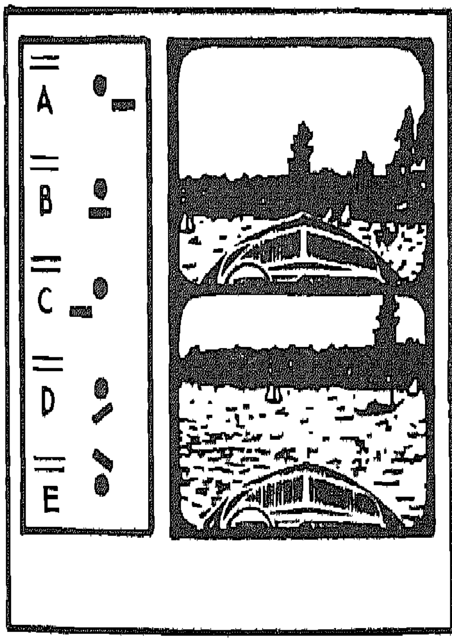


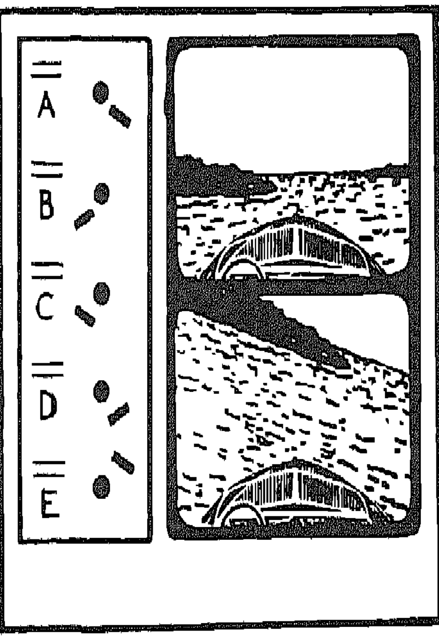
( )

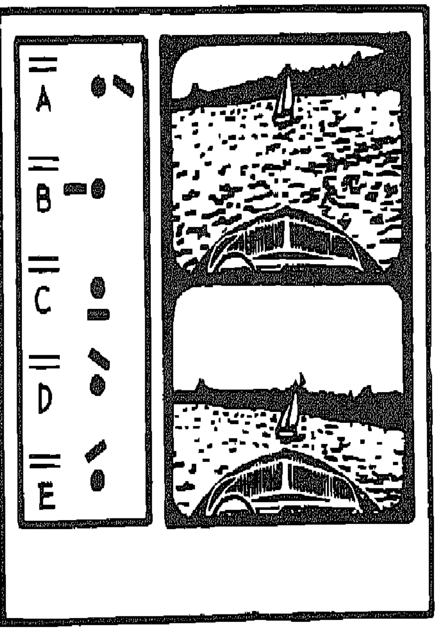
# SPATIAL ORIENTATION

Directions: The 6 items below are similar to the ones you did in the GUILFORD-ZIMMERMAN APTITUDE SURVEY, Spatial Orientation test. Blacken the answer space which shows how the position of the boat has changed in the bottom picture from its original position in the top picture.

(Since the 6 items actually used in the interview came from the body of a copyrighted test, they are not reproduced here. The 3 items below are reproduced from the test directions.)







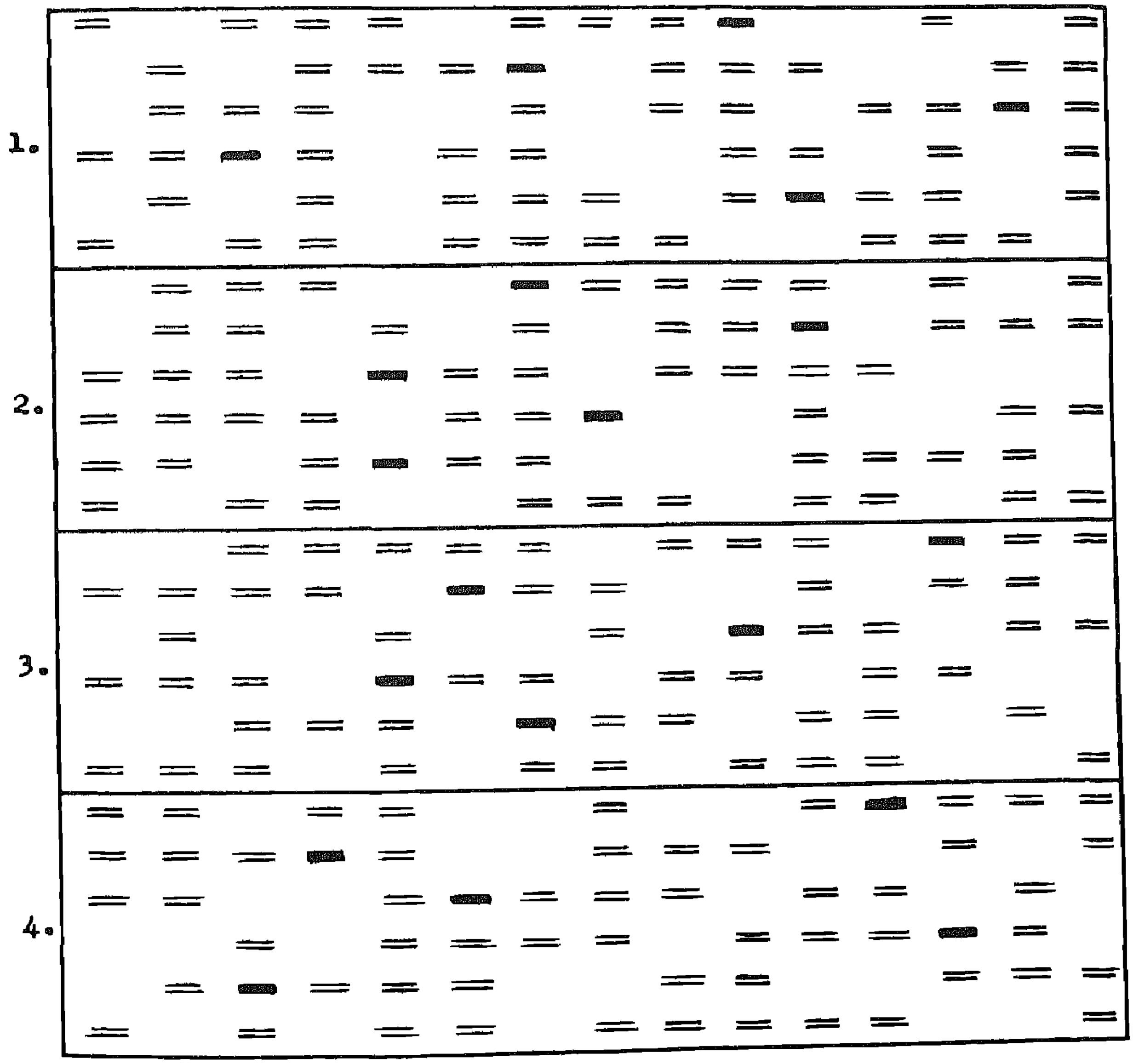
## NUMBER SERIES

Directions: The 5 problems below are similar to the ones which you did in the NUMBER SERIES test. In each line below, find the rule and circle the number at the right which is the next number in the series.

| | Series | | | | | | | Next Number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 12 | 14 | 10 | 7 | 9 | 5 | 2 | 6 | 4 | 5 | 7 | 0 |
| 2. | 17 | 15 | 18 | 9 | 7 | 10 | 5 | 20 | 8 | 2 | 3 | 12 |
| 3. | 27 | 25 | 29 | 30 | 28 | 32 | 33 | 37 | 29 | 31 | 33 | 35 |
| 4. | 2 | 9 | 15 | 3 | 7 | 10 | 5 | 12 | 1 | 11 | 2 | 6 |
| 5. | 7 | 3 | 6 | 9 | 5 | 10 | 13 | 9 | 16 | 8 | 21 | 19 |

# MARKS

Directions: The 4 problems below are similar to the ones you did in the MARKS test. For each problem find the rule by which the mark is located in the first 5 rows. Using this rule, put a mark where it belongs in the sixth row.



# APPENDIX B

# Interviewer Rating Forms

NAME: ____________________________________________

Last First Middle Initial

# EXPERIMENT IN PROBLEM SOLVING TECHNIQUES

(Interviewer Rating Forms)

Educational Testing Service
Princeton, New Jersey

Project 741-11
sponsored by
The Office of Naval Research
1961

| | | | | |
|---|---|---|---|---|
| | a) | d) | g) | j) |
| | b) | e) | h) | k) |
| MATH | c) | f) | i) | l) |

a) Restates the givens and wanteds in own words. 1 2 3 4 5 Σ = ☐

b) Seems to be having trouble understanding a problem (2 or more readings). 1 2 3 4 5 Σ = ☐

c) Says he's having trouble understanding a problem. 1 2 3 4 5 Σ = ☐

d) Any indication of misreading (wrong answer but math o.k., overlooks a point, etc.). 1 2 3 4 5 Σ = ☐

e) Has trouble deciding on a method for solving a problem. 1 2 3 4 5 Σ = ☐

f) Guessing, crude estimation, figures back from alternatives. 1 2 3 4 5 Σ = ☐

g) Computes answer and finds that it is wrong. 1 2 3 4 5 Σ = ☐

h) Checks answer. (after he circles it, or after he states an answer.) 1 2 3 4 5 Σ = ☐

i) System on # 3 and # 4

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. | volumetric | Y | N | 3Y, 4Y | ______ | ① |
| | | | | 3N, 4Y | ______ | ② |
| 4. | algebra or<br>diagram | Y | N | 3Y, 4N | ______ | ③ |
| | | | | 3N, 4N | ______ | ④ |

---

j) Did you have trouble with any of the problems that you answered?

Item 1 2 3 4 5 Σ = ☐ .

If Yes:

k) Did you have trouble because you didn't know what methods to use ______ ① , or because you didn't understand what was wanted ______ ② ?

l) On the problems that you didn't do, did you have trouble because you didn't know what methods to use ______ ① , or because you didn't understand what was wanted ______ ② ?

CUBES ______ a) c)
b) d) ______

a) Geometrical words used in cube comparisons.
(N. G. for 1 cube description only) Σ = ☐

adjacent ___
angle ___
axis ___
base ___
bottom ___

coinciding ___
corner ___
corresponding ___
clockwise ___
diagonal ___

edge ___
horizontal ___
inverse ___
line ___
opposite ___

parallel ___
perpendicular ___
quadrant ___
side ___
symmetry ___

top ___
vertical ___
vertices ___

other ______ ______ ______ ______.

b) Visualization indications used in cube comparisons.
(N. G. for 1 cube description only) Σ = ☐

Movements

hand and/or pencil ___

paper and/or body ___

Mental manipulations

flip (over, around) ___
move, tip ___
swing it around ___
turn, rotate ___
I picture it turning ___

Conclusions

looks all right ___
can see that it's (not) o.k. ___
that's (not) the same ___

other ______________.

c) Reasons for answers. (Base the ratings on explanations.)

| geometrically analyzed cube comparisons, answer is deduced from the relations | answer deduced from comparison of the exact positions of faces, (with or without geometrical analysis of individual cubes) | answer drawn from the use of pointing words, (X will be here, Y will be here, etc.) | no descriptive comparisons, impression, looks right, (rotate this way and X is in the wrong place.) |
|---|---|---|---|
| ______ | ______ | ______ | ______ |
| (item #) | (item #) | (item #) | (item #) |
| ① | ② | ③ | ④ |

d) Would you say that you make 2 separate 90° rotations of the cubes, or that you visualize only one movement of the cubes across their corners?

| always 2 or more | more 2 than 1 | more 1 than 2 | always 1 |
|---|---|---|---|
| ______ | ______ | ______ | ______. |
| ① | ② | ③ | ④ |

a) c) e)

*PUNCHED HOLES* b) d) f)

---

a) Figures the number of holes or folds required. (Figures total first or number for successive steps)

1. Yes ____ , No ____
2. Yes ____ , No ____ 2. Yes ____ ① , 1. Yes, 1. No ____ ② , 2 No ____ ③

b) Says that he has a system for doing the items Yes ____ ① , No ____ ② .

Only count statements made after a preliminary analysis.

c) Geometrical terms used in solutions. Σ = ☐

adjacent ____
angle ____
axis ____
base ____
bottom ____

corner ____
corresponding ____
diagonal ____
dotted ____
edge ____

horizontal ____
inverse ____
line ____
opposite ____
parallel ____

pattern ____
perpendicular ____
quadrant ____
rectangle ____
side ____

square ____
symmetry ____
top ____
triangle ____
vertices ____

other ____ ____ ____ ____ .

d) Visualization indications used in solutions. Σ = ☐

Movements

hand and/or pencil ____

paper and/or body ____

Mental manipulations

flip (over, under, around) ____
fold (over, under, around) ____
a fold, a crease, a bend ____
paper, piece ____
I see it unfolding (folding) ____
I just unfold (fold) these ____

Conclusions

looks all right ____
I look to see where the holes are ____
the holes will be here and here, etc. ____
fold will produce this and this, etc. ____

other ____ .

---

e) Before you figure out where the holes will be, do you try to mentally fold or unfold the paper? No ____ ① , Yes ____ ② .

f) Would you say that you spent more of your time working with the geometrical relations in the figures, or that you spent more of your time determining where the holes would be by mentally unfolding the figures? (a little or considerably more)

much geometry ____ ① , more geom. than vis. ____ ② , more vis. than geom. ____ ③ , much vis. ____ ④ .

LETTER GROUPS: a) ___ b) ___ c) ___ d) ___ e) ___ f) ___ g) ___ h) ___ i) ___ j) ___

a) First:

Brings $H_1$s to problem ______ (item #) ①, Analyzes 1st set ______ (item #) ②, Scans item ______ (item #) ③.

b) Length of scanning time:

None ______ (item #) ①, Short ______ (item #) ②, Long ______ (item #) ③.

c) The # of $H_1$s tried before he gets it.

1 ☐ , 2 ☐ , 3 ☐ , 4 ☐ , 5 ☐ $\Sigma$ = ☐ .

d) Work on the item:

only $H_1$s ______ (item #) ①

alternates between $H_1$s and scanning (just look for it) ______ (item #) ②

only scanning ______ (item #) ③

e) Answers by impression of the pattern. (hasn't any reason for his choice) 1 2 3 4 5 $\Sigma$ = ☐ .

f) Says he's guessing. 1 2 3 4 5 $\Sigma$ = ☐ .

---

g) Would you say that you begin by trying different ideas or that you begin by scanning an item. (Sometimes or always)

always ideas ______ ①, sometimes ideas ______ ②, sometimes scan ______ ③, always scan ______ ④.

h) Would you say that you spent more of your time trying ideas, or that you spent more of your time scanning the letter groups waiting for the answer to pop out at you? (A little or considerably more)

always $H_1$s ______ ①, more $H_1$s than scan. ______ ②, more scan. than $H_1$s ______ ③, always scan. ______ ④.

i) Will you tell me the ideas which you would try in order to figure out the answers to items on a test of this sort? (With paper turned over) $\Sigma$ = ☐

alphabetical order ___
reverse alph. order ___
alternation ___
progression ___

skip letters ___
vowels ___
consonants ___
position ___

common letters ___
single ___
double ___
triple ___
varying # ___

combinations of the ones mentioned ___

j) Do you use these ideas in about the same order each time?. Yes ______ ①, No ______ ②.

SURFACE DEVELOPMENT a) b) c) d) e) ______

a) Geometrical words used in solution. Σ = ☐

adjacent ___
angle ___
axis ___
base ___
bottom ___
coinciding ___

corner ___
corresponding ___
diagonal ___
dotted ___
edge ___
follow ___

horizontal ___
inverse ___
line ___
opposite ___
parallel ___
perpendicular ___

rectangle ___
side ___
square ___
symmetry ___
top ___
triangle ___

vertices ___
work around ___

others ______ ______ ______ ______.

b) Visualization indications used in solution. Σ = ☐

Movements

hand and/or pencil ___

paper and/or body ___

Mental manipulations

flip (over, under, around) ___
fold, bend (over, under, around) ___
a fold, a bend, a crease ___
paper, piece, surface ___
up and over, down and around, etc. ___
tuck, close, construct ___
I see it folding (bending) ___

Conclusions

folding will produce this and this ___
it looks right ___
this goes here, and this goes here ___
can see that it's o.k. ___
I just look at it and write down the answers ___

other ______________.

c) Reasons for answers.

| | | | |
|---|---|---|---|
| strictly geometrical analysis, (angles, and the like or, tracing around) | some geometry or tracing and some folding action reasons | all folding action reasons | just looks at it and sees the answer, impression |
| ______ | ______ | ______ | ______ |
| (item #)<br>① | (item #)<br>② | (item #)<br>③ | (item #)<br>④ |

d) Do you begin work on this type of item by mentally folding the cut-out? No ___ ①, Yes ___ ②.

e) Would you say that you spent more of your time working with the geometrical relationships in the diagram, or that you spent more of your time mentally folding the cut-out to see where the pieces fit? (A little or considerably more)

much geometry ___ ①, more geom. than vis. ___ ②, more vis. than geom. ___ ③, much vis. ___ ④.

VERBAL ANALOGIES a) b) c) d) e) f)

a) The number of comparative characteristics of the stem words stated. (Definitions of only one word - N. G.)

Tally

| Item | 1 | 2 | 3 | 4 |  |
|---|---|---|---|---|---|
| Initial |  |  |  |  | $\frac{\Sigma}{n} = \boxed{\quad}$ |
| Other |  |  |  |  | $\frac{\Sigma}{n} = \boxed{\quad}$ |

b) 100 - % time spent on the stems initially.

| Item | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Seconds on stem |  |  |  |  |

$\frac{\Sigma}{\text{Total time on the 4 items}} = \_\_\_\_\_ =$

100.0

- .

$\boxed{\quad . \quad}$ %

c) Alternatives

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| tentative acceptance and/or rejection, 1-5 in order | tentative acceptance and/or rejection, any order | scans test, rejects one or two, then makes a choice | scans list, chooses one, then eliminates some or all others | scans list, chooses one, sees it right off, doesn't eliminate | scans list, chooses one, impression, vague, no eliminations |
| _____ | _____ | _____ | _____ | _____ | _____ |
| (item #) | (item #) | (item #) | (item #) | (item #) | (item #) |
| ① | ② | ③ | ④ | ⑤ | ⑥ |

d) Gives a reason for his answer. Yes ______ (item #) ①, No ______ (item #) ② .

---

e) When you start going through the options, do you figure the relationship in each, do you simply check each for a relationship which you found in the stem, or do you scan the options to see if something will pop out at you? (Sometimes or always)

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| always relations | always checking | sometimes relations | sometimes checking | sometimes scanning | always scanning |
| _____ | _____ | _____ | _____ | _____ | _____ |
| ① | ② | ③ | ④ | ⑤ | ⑥ |

f) Would you say that you spent more of your time figuring and checking relationships, or that you spent more of your time scanning the items waiting for an answer to pop out at you? (A little or considerably more)

|  |  |  |  |
|---|---|---|---|
| much relations _____ , | more rel. than scan. _____ , | more scan. than rel. _____ , | much scan. _____ . |
| ① | ② | ③ | ④ |

CARDS ______ a) ______ b) ______ c) ______ d) ______ e) ______ f) ______ g) ______ h) ______ i)

a) Stem: (includes analysis of stem and 1st alternative together)

| geometrical analysis of stem first | scans item, then geometrical analysis of stem | gross analysis of stem first ("hole's on the left") | scans item, then gross analysis of stem | glances at stem and immediately begins on alternatives |
|---|---|---|---|---|
| ______ | ______ | ______ | ______ | ______ |
| (item #) | (item #) | (item #) | (item #) | (item #) |
| ① | ② | ③ | ④ | ⑤ |

b) Geometrical Analysis:

1. stem ______
2. alternatives ______

1&2 ______ ① , 2 ______ ② , 1 ______ ③ , none ______ ④ .

c) Says that he has a system for doing the items. Yes ______ ① , No ______ ② .

Terms used at any time:

d) Geometrical terms used to decide on alternatives. Σ = ☐

| | | | | |
|---|---|---|---|---|
| adjacent ___ | coinciding ___ | diagonal ___ | line ___ | quadrant ___ |
| angle ___ | corner ___ | edge ___ | opposite ___ | reverse ___ |
| axis ___ | corresponding ___ | follow ___ | parallel ___ | side ___ |
| base ___ | clockwise ___ | horizontal ___ | perpendicular ___ | symmetry ___ |
| bottom ___ | curve ___ | inverse ___ | precede ___ | top ___ |

other ______ ______ ______ ______

e) Visualization indications used to decide on alternatives. Σ = ☐

| Movements | Mental manipulation terms | Conclusions |
|---|---|---|
| hand and/or pencil ___ | flip, turn, swing ___ | flip over and the hole's o.k. ___ |
| paper and/or body ___ | rotate (over or around) ___ | looks right, fits ___ |
| | paper, piece ___ | just flip them over ___ |
| | I see it turning ___ | that is (not) the same ___ |

other ______________ .

f) Uses a rejecting characteristic ______ ① (item #) , rejects by impression ______ ② (item #) .

g) Accepts by using a rule ______ (item #) ① , Accepts by visualizing the rotation ("just see it," rotate and look) ______ (item #) ②

---

h) Do you begin by figuring out a rule for the geometrical relationships in the stem? Yes ___ ① , No ___ ② .

i) Would you say that you spent more of your time figuring the answers from rules about the geometrical relationships in the cards, or that you spent more of your time mentally rotating the cards and checking to see if they looked right? (A little or considerably more)

much geom. ______ ① , more geom. than rot. ______ ② , more rot. than geom. ______ ③ , much rotation ______ ④ .

| READING | a) | c) | e) | g) | i) | k) |
|---|---|---|---|---|---|---|
| | b) | d) | f) | h) | j) | l) |

a) % of time spent reading paragraph.

$$\frac{\text{Reading (seconds)}}{\text{Total}} = \_\_\_\_\_\_\_\_ = \boxed{\quad . \quad}\ \%$$

b) Reads paragraph first _____ ① , reads questions first _____ ② .

c) Answers the questions as he reads. No _____ ① , Yes _____ ② .

d) Uses underlining or other observable notations. Yes _____ ① , No _____ ② .

e) After reading the stem:

| | | | | | | |
|---|---|---|---|---|---|---|
| Figures out answer before looking at the alternatives or the paragraph | Reads alternatives, and then figures answer before looking at the paragraph | Finds answer in the context before looking at the alternatives | Reads alternatives, tentative choice, then finds answer in context | Reads alternatives, tentative choice, then tries to spot alternative | Reads alternatives, no choice, then finds answer in context | Reads alternatives, no choice, then tries to spot alternatives |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| (item #) | (item #) | (item #) | (item #) | (item #) | (item #) | (item #) |
| ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

f) Scans the list first. No _____ , Yes _____ .
① (item #) ② (item #)

g) Tentative acceptance or rejection:

In order _____ , Not in order _____ , Some _____ , Doesn't do it _____ .
① (item #) ② (item #) ③ (item #) ④ (item #)

h) Gives reason for answer. (or remembers) Yes _____ , No _____ .
① (item #) ② (item #)

i) # of returns to paragraph. (before he gets the answer) Item ≤ 2

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | | | |

Σ = ☐ .

---

j) As you read the paragraph, did you try to note particular points, or did you read it straight through for the general impression? – (A little or considerably)

note considerably _____ ① , note little _____ ② , impression little _____ ③ , impression considerably _____ ④ .

k) Which do you usually read first: the paragraph or the questions?

Paragraph _____ ① , Questions _____ ② .

l) When you start going through the options do you usually have an idea of what the answer should be and then just look for it, do you reject some and tentatively accept others, or do you scan the options and wait to see if something will pop out at you?

idea already _____ ①

rejection and tentative acceptance _____ ②

scan options _____ ③

| | | | | | |
|---|---|---|---|---|---|
| | a) | c) | e) | g) | i) |
| CONCEALED FIGURES | b) | d) | f) | h) | |

a) Relative speed of acceptance and rejection.

faster rejection _____ ①, about the same speed _____ ②, faster acceptance _____ ③.

b) Uses a rejecting characteristic _______ (item #) ①, rejects by impression _______ (item #) ②.

c) Accepts part by part (spoken or traced) _______ (item #) ①, Accepts by superimposing ("just sees it") _______ (item #) ②.

d) Illusions (independent of right or wrong marking).

| not slowed, says nothing | not slowed, acknowledged the illusion and ignores it | is slowed, says nothing | indicates trouble seeing whether or not the figure is present when it has an illusion |
|---|---|---|---|
| _______ | _______ | _______ | _______ |
| (item #) | (item #) | (item #) | (item #) |
| ① | ② | ③ | ④ |

e) # of correct figures with an illusion which were marked —

tally ☐ 0 1 2 3 4

---

f) Point to the four figures which were most confusing for you. (Count if they contain illusions.)

tally ☐ 0 1 2 3 4

g) Do you think that you mark the right ones slower _____ ①, about the same speed as _____ ②, or faster than _____ ③ you mark the wrong ones?

h) When you decide that a figure does contain the original, do you make your decision after looking for specific parts of the original _____ ①, or do you just try to see the whole original figure in it _____ ②?

i) When you decide that a figure does not contain the original, do you make your decision after looking for specific missing parts _____ ①, or do you decide by just seeing that the original figure won't fit _____ ②?

|  | a) | c) | e) | g) |
|---|---|---|---|---|
| SPATIAL ORIENTATION | b) | d) | f) |  |

a) Mechanical rule for angle of tilt given before solutions are started. (If x happens, it means that ...)

Yes ______ ①, No ______ ② .

b) Geometrical terms used in solutions. Σ = ☐

adjacent ____
angle ____
axis ____
bottom ____

coinciding ____
corner ____
corresponding ____
clockwise ____

diagonal ____
edge ____
horizontal ____
inverse ____

level ____
line ____
parallel ____
perpendicular ____

side ____
square ____
top ____

Other ____________ ____________ ____________ ____________

c) Visualization terms used in solutions. Σ = ☐

Movements

hand and/or pencil ____
paper and/or body ____

Mental Manipulations

flips (up, down, over) ____
straighten out, twist, turn, swing around . ____
rise, come up, above, ____
fall, below, drop ____

Mental Manipulations

throttles up or down ____
advances, comes closer, backs off ____
I picture (see) it moving ____
I imagine myself in the boat ____

Other ______________________________

d) Eliminates alternatives by figuring factors separately.

Yes ________ (item #) ①, No ________ (item #) ② .

e) Notices that the answer for item 4 is not given.

Yes ________ ①, No ________ ② .

---

f) How do you figure out the way that the boat has tilted? Do you use a rule based on the geometrical characteristics of the pictures, or do you visualize the boat being driven?

rule _____ ①, visualize _____ ② .

g) Would you say that you spent more of your time working with the geometrical relationships between the sets of pictures, or that you spent more of your time figuring the answers by visualizing the boat being driven? (A little or considerably more)

Always geom. _____ ①, more geom. than vis. _____ ②, more vis. than geom. _____ ③, always vis. _____ ④ .

a) d) g) j)
b) e) h)
NUMBER SERIES c) f) i)

a) First: Relationships ______ (item #) ①, Scanning ______ (item #) ② .

b) Work on the item
All relationships ______ (item #) ①, Alternates between relations and scanning ______ (item #) ② .

c) The number of relationships figured.
All ______ (item #) ①, Some ______ (item #) ②, None ______ (item #) ③ .

d) Answers by impression of the pattern. (visually sees it, or thinks he has figured it out.) 1 2 3 4 5 Σ = ☐

e) Looks for skipping patterns. 1 2 3 4 5 Σ = ☐

f) Length of scanning time.
None ______ (item #) ①, Short ______ (item #) ②, Long ______ (item #) ③ .

g) Says he's guessing. Item 1 2 3 4 5 Σ = ☐ .

h) Flexibility (uses multiplication and/or division on items 2, 4, and 5)

tabulation

2 Y N
4 Y N 4 + 2
5 Y N

2, 4 + 5 ______ ①
or 4 + 5 ______ ②
2 + 5 ______ ③

4 ______ ④
2 or 5 ______ ⑤
none ______ ⑥

---

i) Would you say that you start by figuring relationships, or that you first scan the item to see if a pattern is readily apparent? (Sometimes or always)

Always relations ______ ①, sometimes relations ______ ②, sometimes scan ______ ③, always scan ______ ④ .

j) Would you say that you spent more of your time figuring the exact relationships between the numbers, or that you spent more of your time scanning the items looking for a pattern in the numbers? (A little or considerably more)

much relations ______ ①, more rel. than scanning ______ ②, more scanning than rel. ______ ③, much scanning ______ ④ .

MARKS a) b) c) d) e) f) g) h) i) j)

---

a) First:

Brings $H_1$s to problem ______ (item #) ① , Analyzes 1st set ______ (item #) ② , Scans item ______ (item #) ③ .

b) Length of scanning time:

None ______ (item #) ① , Short ______ (item #) ② , Long ______ (item #) ③ .

c) The # of $H_1$s tried before he gets it.

1 ☐ , 2 ☐ , 3 ☐ , 4 ☐ Σ = ☐ .

d) Work on the item:

only $H_1$s ______ (item #) ①

alternates between $H_1$s and scanning (just look for it) ______ (item #) ②

only scanning ______ (item #) ③

e) Answers by impression of the pattern. (hasn't any reason for his choice) 1 2 3 4 Σ = ☐ .

f) Says he's guessing. 1 2 3 4 Σ = ☐ .

---

g) When you started on a new item did you first try different ideas or did you first scan through the item to see if you could find a pattern? (Always or sometimes)

always ideas ______ ① , sometimes ideas ______ ② , sometimes scan ______ ③ , always scan ______ ④ .

h) Would you say that you spent more of your time trying different ideas, or that you spent more of your time scanning the items looking for the pattern? (A little or considerably more)

all ideas ______ ① , more ideas than scan. ______ ② , more scan. than ideas ______ ③ , all scan. ______ ④ .

i) Will you tell me all of the ideas which you try in order to figure out the answers to items on a test of this sort?

count from end ______
position in a group ______
size group it's in ______
relation to gap ______
which of given size group it is in ______
look for alternating position with group ______
numerical pattern down through the rows ______

Σ = ☐

j) Do you take these in about the same order each time? Yes ______ ① , No ______ ② .

# APPENDIX C

## Questionnaire

Educational Testing Service
20 Nassau St., Princeton, N. J.

## Study of Test Taking Methods

Name ________________________ Age ______ Class ______

Major (or expected major) ________________________

Father's Occupation ________________________

List your out-of-school hobbies and indicate the extent to which you have been involved in these activities.

________________________

________________________

________________________

________________________

________________________

List the extra-curricular activities in which you have participated (high school and/or college).

________________________

________________________

________________________

Which of the following mathematics courses did you have in high school? (Check)

1st yr. Algebra ______
2nd yr. Algebra ______
Plane Geometry ______
Solid Geometry ______

Trigonometry ______
Introductory Calculus ______
Other ______
______

How many semesters of mathematics have you had in college? ______

How many semesters of applied art (painting, drawing, etc.) and mechanical drawing have you had?

| | 9th-12th Grade | College |
|---|---|---|
| Applied Art | ______ | ______ |
| Mechanical Drawing | ______ | ______ |

How many semesters of each of the following have you had in college?

Engineering (other than mechanical drawing) ______
Architecture ______

Please rank the three types of tests listed below according to how well you think you generally do on them, in comparison with your fellow students. (Indicate: 1st, 2nd, 3rd)

Tests of mathematics and reasoning ______
Tests of visualizing and space ______
Tests of words and reading ______

How did the way that you worked items on the tests compare with the way that you worked the similar items during the interview?

About the same ______

Differently ______

(If differently, check any and all applicable descriptions.)

______ discovered different methods for several tests during the interview.

______ was much more systematic in the interview.

______ was much less systematic in the interview.

______ tend to think much more clearly aloud.

______ tend to think much less clearly aloud.

Name 1, 2 or 3 occupations that you think you might like to enter after graduation from college.

________________________________________

________________________________________

________________________________________

Name 1, 2 or 3 occupations of college graduate calibre that you think you would particularly dislike entering.

________________________________________

________________________________________

________________________________________

Considering the different ways in which test problems may be solved, please write below anything which you think:

1. describes the ways in which you solve test problems.
2. distinguishes your methods from those of some of your fellow students in college.

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

# APPENDIX D

## Intercorrelations and Varimax Factor Loadings for the Whole Group

2731
U-6(6)?

Intercorrelations of 15 Tests for the Whole Group

| | Test Names | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Vocabulary | | 60 | 26 | 27 | 41 | 23 | 72 | 46 | 13 | 72 | 31 | 31 | 35 | 35 | 16 |
| 2. | Math. Problems | 60 | | 34 | 48 | 46 | 40 | 59 | 58 | 36 | 60 | 42 | 42 | 42 | 64 | 29 |
| 3. | Cubes | 26 | 34 | | 46 | 41 | 57 | 29 | 38 | 47 | 39 | 47 | 46 | 45 | 15 | 22 |
| 4. | Punched Holes | 27 | 48 | 46 | | 35 | 61 | 30 | 45 | 52 | 37 | 60 | 57 | 49 | 31 | 37 |
| 5. | Letter Grouping | 41 | 46 | 41 | 35 | | 30 | 39 | 43 | 39 | 43 | 45 | 44 | 32 | 50 | 30 |
| 6. | Surface Dev. | 23 | 40 | 57 | 61 | 30 | | 30 | 39 | 66 | 30 | 61 | 59 | 56 | 18 | 17 |
| 7. | Verbal Analogies | 72 | 59 | 29 | 30 | 39 | 30 | | 48 | 26 | 72 | 31 | 38 | 42 | 37 | 26 |
| 8. | Ship Destination | 46 | 58 | 38 | 45 | 43 | 39 | 48 | | 37 | 53 | 49 | 52 | 45 | 41 | 45 |
| 9. | Cards | 13 | 36 | 47 | 52 | 39 | 66 | 26 | 37 | | 23 | 58 | 50 | 47 | 24 | 24 |
| 10. | Reading | 72 | 60 | 39 | 37 | 43 | 30 | 72 | 53 | 23 | | 36 | 36 | 44 | 37 | 28 |
| 11. | Concealed Figures | 31 | 43 | 47 | 60 | 45 | 61 | 31 | 49 | 58 | 36 | | 56 | 50 | 29 | 35 |
| 12. | Figure Analogies | 31 | 42 | 46 | 57 | 44 | 59 | 38 | 52 | 50 | 36 | 56 | | 56 | 32 | 31 |
| 13. | Spatial Orient. | 35 | 42 | 45 | 49 | 32 | 56 | 42 | 45 | 47 | 44 | 50 | 56 | | 29 | 32 |
| 14. | Number Series | 35 | 64 | 15 | 31 | 50 | 18 | 37 | 41 | 24 | 37 | 29 | 32 | 29 | | 29 |
| 15. | Marks | 16 | 29 | 22 | 37 | 30 | 17 | 26 | 45 | 24 | 28 | 35 | 31 | 32 | 29 | |

Means, Standard Deviations, and Varimax Factor Loadings for the Whole Group

| | Test Names | M. | S.D. | A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|
| 1. | Vocabulary | 22.4 | 8.2 | .12 | .84 | .18 | .04 | .11 |
| 2. | Math. Problems | 12.3 | 3.1 | .32 | .54 | .61 | .14 | -.02 |
| 3. | Cubes | 13.2 | 8.2 | .60 | .22 | -.01 | .10 | .23 |
| 4. | Punched Holes | 47.8 | 16.9 | .65 | .16 | .20 | .28 | -.01 |
| 5. | Letter Grouping | 15.0 | 3.9 | .31 | .28 | .34 | .19 | .54 |
| 6. | Surface Dev. | 28.0 | 13.1 | .90 | .14 | .07 | -.04 | -.05 |
| 7. | Verbal Analogies | 8.6 | 3.6 | .20 | .77 | .17 | .14 | .05 |
| 8. | Ship Destination | 39.5 | 7.9 | .37 | .40 | .26 | .45 | .07 |
| 9. | Cards | 66.5 | 22.5 | .72 | .03 | .16 | .09 | .13 |
| 10. | Reading | 10.0 | 3.4 | .22 | .80 | .13 | .20 | .12 |
| 11. | Concealed Figures | 70.8 | 20.6 | .67 | .17 | .15 | .27 | .16 |
| 12. | Figure Analogies | 16.4 | 4.4 | .63 | .22 | .15 | .27 | .12 |
| 13. | Spatial Orient. | 25.9 | 11.9 | .58 | .31 | .10 | .24 | -.00 |
| 14. | Number Series | 24.6 | 4.5 | .12 | .23 | .73 | .20 | .17 |
| 15. | Marks | 9.5 | 3.0 | .10 | .12 | .14 | .60 | .08 |

P N.I.E.L.D.U (N.C.E.R.T.)

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